

ANALYST'S LABORATORY COLLECTION

THE ANALYST'S LABORATORY COMPANION

*A COLLECTION OF TESTS AND REAGENTS FOR THE USE OF
PURE AND GENERAL ANALYSES, SPECIAL QUALITY
RESOURCES, AND WORKS OF ANALYSIS, AND SPECIAL
TOGETHER WITH NUMEROUS EXAMPLES OF CHEMICAL
CALCULATIONS AND VARIOUS DESCRIPTIONS OF SPECIAL
ANALYTICAL PROCESSES*

BY

ALFRED E. JOHNSON, B.S., D.D.
OF THE UNIVERSITY OF CALIFORNIA

FIFTH EDITION

THOROUGHLY REVISED WITH ADDITIONS



LONDON
J. & A. CHURCHILL
7 GREAT MARLBOROUGH STREET
1920

PREFACE TO THE FIFTH EDITION

[illegible]

The first advantage of the new design is that it is simpler. The old design was a complex machine with many parts, and it was difficult to use. The new design is simpler and easier to use. It has fewer parts and is easier to maintain. It is also more reliable and has a longer life span. The new design is also more efficient and saves time. It is a great improvement over the old design.

[illegible][illegible]

The following table shows the percentage of the population aged 15 years and over who are employed in the manufacturing sector.

The OHS, Fair Labor Wave, and the Fair Trade Movement will add to the existing literature on the role of labor in the production of the movement of the 1990s. The author's goal is

Several additional calculations have been made to the effect of varying the number of work days per year.

The data on Heat and Temperature of dry have been corrected, with addition

The following tables have been revised and brought up to date: Meeting point of Metals, Mineral Analysis, Weights and Measures, Foreign Weights and Measures, Food and Drugs, Common Substances, Vapor Pressure of Mercury, Specific Heats of Sulphuric Acid and Ammonia, Standards of Sewage Effluents, etc. I have also amplified the Index.

A. L. JOHNSON*

CONTENTS.

Atomic Weights for 1921,	1
Logarithmic Table	2
Densities of Gases,	7
Freezing Melting,	7
Melting Points of Metals,	8
Gravimetric Factors,	9
Volumetric Factors,	23
Nitrogen Analysis,	29
Correction of the End Solution for Temperature,	30
Coefficient of Absorption Coeff. in Water,	30
Table of Reciprocals,	31
Various Useful Factors and Data	32
Notation Logarithms	33
Computation,	36
Approximations	37
Indirect Analysis,	41
Precipitating Powers of the Common Reagents,	43
Percentage Composition of commonly occurring Compounds,	44
Notes on Indicators,	54
Weights and Measures,	56
Atomic Weights and their English Equivalents	63
Densities of commonly occurring Substances,	64
Percentage into cwt., qts., and lbs. per ton, etc.,	66
Drams per lb. into Percentage, etc.,	66
Barometric Tables,	67

	PAGE
Correction of Gaseous Volumes for Temperature	68
Tension of Mercury Vapour	71
Volume and Density of Water at Different Temperatures	72
Baumé Hydrometer	73
Specific Gravity Tables (English)	74
Strength of Saturated Solutions	75
Viscosity Table	79
Propanol and Isopropanol in Water Analysis	80
Water Analysis Table	89
Defalcation of Neutral in Water	89
Water and Sewerage Engineering Rules	96
Standard for Sewerage Collection	97
Disinfecting Capacity of Chlorine	98
Table of Boiling Points	100
Gravimetric Analysis	100
Specific Gravity of Water	100
Capacity of Power Plants and Boilers	111
Analysis Table	119
Alcohol Table	121
Alcohol Content Table	126
Correction of Alcohol to Temperature	127
Density of Gases	128
Phosphorus Tables	129
Nitrogen, Ammonia and Ammoniums Table	137
Kjeldahl Table	139
Factors for Calculating Nitrogenous Substances	140
Oils, Fats, and Waxes	141
Constants of Oils, Fats, and Waxes	143
Pelletier's Acid Values	146
Butter Analysis	149
Sale of Butter Regulations, 1902	151
Milk Analysis	152
Sale of Milk Regulations, 1901	153

CONTENTS.

ix

Preservatives in Milk and Cheese	153
Quinine	156
Gallies and Chelery	157
Lead in Tartare and in the Acid, and in the Oil of Tartar	157
Food Preservatives	159
Arsenic in Food	16
Data in Heat and Thermodynamics	160
Thompson's Calorimeter	160
Electric Units	164
Electro-Chemical Effects	165
Thermometric Table	166
INDEX	172

COMMON LOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
0	0	00432	0 00432	01284	01703	02110	02501	0 028 02842	03743										
1	04139	04532	04922	05308	05690	06070	06446	0 068 06846	07554										
2	07918	08279	08636	08991	09342	09690	10037	0 104 10421	11059										
3	11344	11727	12107	12485	12861	13235	13604	0 140 13672	14268										
4	14614	14992	15369	15744	16116	16487	16856	0 172 16822	17419										
5	17809	18188	18564	18939	19312	19683	20052	0 204 19618	20416										
6	20791	21158	21522	21885	22245	22604	22961	0 232 22527	23586										
7	23945	24303	24658	25012	25364	25715	26064	0 264 25630	26589										
8	26437	26788	27137	27485	27831	28176	28519	0 288 28085	29144										
9	28777	29117	29456	29793	30129	30463	30796	0 312 30362	31421										
10	31019	31359	31697	32034	32369	32702	33034	0 324 31600	32659										
11	32229	32567	32903	33238	33571	33903	34234	0 344 33000	34059										
12	34392	34729	35064	35398	35730	36061	36391	0 364 35000	36059										
13	36492	36829	37164	37498	37830	38161	38491	0 384 37000	38059										
14	38692	39029	39364	39698	40030	40361	40691	0 404 39000	40059										
15	40791	41129	41464	41798	42130	42461	42791	0 424 41000	42059										
16	42992	43329	43664	43998	44330	44661	44991	0 444 43000	44059										
17	45192	45529	45864	46198	46530	46861	47191	0 464 45000	46059										
18	47392	47729	48064	48398	48730	49061	49391	0 484 47000	48059										
19	49592	49929	50264	50598	50930	51261	51591	0 512 49000	50059										

COMMON LOGARITHMS (continued)

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
20	51792	52129	52464	52798	53130	53461	53791	0 532 51000	52059										
21	53992	54329	54664	54998	55330	55661	55991	0 552 53000	54059										
22	56192	56529	56864	57198	57530	57861	58191	0 572 55000	56059										
23	58392	58729	59064	59398	59730	60061	60391	0 592 57000	58059										
24	60592	60929	61264	61598	61930	62261	62591	0 612 59000	60059										
25	62792	63129	63464	63798	64130	64461	64791	0 624 61000	62059										
26	64992	65329	65664	65998	66330	66661	66991	0 644 63000	64059										
27	67192	67529	67864	68198	68530	68861	69191	0 664 65000	66059										
28	69392	69729	70064	70398	70730	71061	71391	0 684 67000	68059										
29	71592	71929	72264	72598	72930	73261	73591	0 704 69000	70059										
30	73792	74129	74464	74798	75130	75461	75791	0 724 71000	72059										
31	75992	76329	76664	76998	77330	77661	77991	0 744 73000	74059										
32	78192	78529	78864	79198	79530	79861	80191	0 764 75000	76059										
33	80392	80729	81064	81398	81730	82061	82391	0 784 77000	78059										
34	82592	82929	83264	83598	83930	84261	84591	0 804 79000	80059										
35	84792	85129	85464	85798	86130	86461	86791	0 824 81000	82059										
36	86992	87329	87664	87998	88330	88661	88991	0 844 83000	84059										
37	89192	89529	89864	90198	90530	90861	91191	0 864 85000	86059										
38	91392	91729	92064	92398	92730	93061	93391	0 884 87000	88059										
39	93592	93929	94264	94598	94930	95261	95591	0 904 89000	90059										
40	95792	96129	96464	96798	97130	97461	97791	0 924 91000	92059										
41	97992	98329	98664	98998	99330	99661	99991	0 944 93000	94059										
42	100192	100529	100864	101198	101530	101861	102191	0 964 95000	96059										
43	102392	102729	103064	103398	103730	104061	104391	0 984 97000	98059										
44	104592	104929	105264	105598	105930	106261	106591	0 1004 99000	100059										
45	106792	107129	107464	107798	108130	108461	108791	0 1024 101000	102059										
46	108992	109329	109664	109998	110330	110661	110991	0 1044 103000	104059										
47	111192	111529	111864	112198	112530	112861	113191	0 1064 105000	106059										
48	113392	113729	114064	114398	114730	115061	115391	0 1084 107000	108059										
49	115592	115929	116264	116598	116930	117261	117591	0 1104 109000	110059										

Not. The logarithms of numbers 1 to 10 are the same as those of 10, 20, 30, etc.

COMMON LOGARITHMS. (continued).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
50	6989	6998	7007	7016	7025	7034	7043	7052	7061	7070	7079	7088	7097	7106	7115	7124	7133	7142	7151	7160
51	7069	7078	7087	7096	7105	7114	7123	7132	7141	7150	7159	7168	7177	7186	7195	7204	7213	7222	7231	7240
52	7149	7158	7167	7176	7185	7194	7203	7212	7221	7230	7239	7248	7257	7266	7275	7284	7293	7302	7311	7320
53	7229	7238	7247	7256	7265	7274	7283	7292	7301	7310	7319	7328	7337	7346	7355	7364	7373	7382	7391	7400
54	7309	7318	7327	7336	7345	7354	7363	7372	7381	7390	7399	7408	7417	7426	7435	7444	7453	7462	7471	7480
55	7489	7498	7507	7516	7525	7534	7543	7552	7561	7570	7579	7588	7597	7606	7615	7624	7633	7642	7651	7660
56	7669	7678	7687	7696	7705	7714	7723	7732	7741	7750	7759	7768	7777	7786	7795	7804	7813	7822	7831	7840
57	7849	7858	7867	7876	7885	7894	7903	7912	7921	7930	7939	7948	7957	7966	7975	7984	7993	8002	8011	8020
58	8029	8038	8047	8056	8065	8074	8083	8092	8101	8110	8119	8128	8137	8146	8155	8164	8173	8182	8191	8200
59	8209	8218	8227	8236	8245	8254	8263	8272	8281	8290	8299	8308	8317	8326	8335	8344	8353	8362	8371	8380
60	8389	8398	8407	8416	8425	8434	8443	8452	8461	8470	8479	8488	8497	8506	8515	8524	8533	8542	8551	8560
61	8569	8578	8587	8596	8605	8614	8623	8632	8641	8650	8659	8668	8677	8686	8695	8704	8713	8722	8731	8740
62	8749	8758	8767	8776	8785	8794	8803	8812	8821	8830	8839	8848	8857	8866	8875	8884	8893	8902	8911	8920
63	8929	8938	8947	8956	8965	8974	8983	8992	9001	9010	9019	9028	9037	9046	9055	9064	9073	9082	9091	9100
64	9109	9118	9127	9136	9145	9154	9163	9172	9181	9190	9199	9208	9217	9226	9235	9244	9253	9262	9271	9280
65	9289	9298	9307	9316	9325	9334	9343	9352	9361	9370	9379	9388	9397	9406	9415	9424	9433	9442	9451	9460
66	9469	9478	9487	9496	9505	9514	9523	9532	9541	9550	9559	9568	9577	9586	9595	9604	9613	9622	9631	9640
67	9649	9658	9667	9676	9685	9694	9703	9712	9721	9730	9739	9748	9757	9766	9775	9784	9793	9802	9811	9820
68	9829	9838	9847	9856	9865	9874	9883	9892	9901	9910	9919	9928	9937	9946	9955	9964	9973	9982	9991	1000
69	1009	1018	1027	1036	1045	1054	1063	1072	1081	1090	1099	1108	1117	1126	1135	1144	1153	1162	1171	1180

COMMON LOGARITHMS. (continued).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
70	8410	8419	8428	8437	8446	8455	8464	8473	8482	8491	8500	8509	8518	8527	8536	8545	8554	8563	8572	8581
71	8590	8599	8608	8617	8626	8635	8644	8653	8662	8671	8680	8689	8698	8707	8716	8725	8734	8743	8752	8761
72	8770	8779	8788	8797	8806	8815	8824	8833	8842	8851	8860	8869	8878	8887	8896	8905	8914	8923	8932	8941
73	8950	8959	8968	8977	8986	8995	9004	9013	9022	9031	9040	9049	9058	9067	9076	9085	9094	9103	9112	9121
74	9130	9139	9148	9157	9166	9175	9184	9193	9202	9211	9220	9229	9238	9247	9256	9265	9274	9283	9292	9301
75	9310	9319	9328	9337	9346	9355	9364	9373	9382	9391	9400	9409	9418	9427	9436	9445	9454	9463	9472	9481
76	9490	9499	9508	9517	9526	9535	9544	9553	9562	9571	9580	9589	9598	9607	9616	9625	9634	9643	9652	9661
77	9670	9679	9688	9697	9706	9715	9724	9733	9742	9751	9760	9769	9778	9787	9796	9805	9814	9823	9832	9841
78	9850	9859	9868	9877	9886	9895	9904	9913	9922	9931	9940	9949	9958	9967	9976	9985	9994	1003	1012	1021
79	1030	1039	1048	1057	1066	1075	1084	1093	1102	1111	1120	1129	1138	1147	1156	1165	1174	1183	1192	1201
80	1210	1219	1228	1237	1246	1255	1264	1273	1282	1291	1300	1309	1318	1327	1336	1345	1354	1363	1372	1381
81	1390	1399	1408	1417	1426	1435	1444	1453	1462	1471	1480	1489	1498	1507	1516	1525	1534	1543	1552	1561
82	1570	1579	1588	1597	1606	1615	1624	1633	1642	1651	1660	1669	1678	1687	1696	1705	1714	1723	1732	1741
83	1750	1759	1768	1777	1786	1795	1804	1813	1822	1831	1840	1849	1858	1867	1876	1885	1894	1903	1912	1921
84	1930	1939	1948	1957	1966	1975	1984	1993	2002	2011	2020	2029	2038	2047	2056	2065	2074	2083	2092	2101
85	2110	2119	2128	2137	2146	2155	2164	2173	2182	2191	2200	2209	2218	2227	2236	2245	2254	2263	2272	2281
86	2290	2299	2308	2317	2326	2335	2344	2353	2362	2371	2380	2389	2398	2407	2416	2425	2434	2443	2452	2461
87	2470	2479	2488	2497	2506	2515	2524	2533	2542	2551	2560	2569	2578	2587	2596	2605	2614	2623	2632	2641
88	2650	2659	2668	2677	2686	2695	2704	2713	2722	2731	2740	2749	2758	2767	2776	2785	2794	2803	2812	2821
89	2830	2839	2848	2857	2866	2875	2884	2893	2902	2911	2920	2929	2938	2947	2956	2965	2974	2983	2992	3001

COMMON LOGARITHMS (continued).

	0	1	2	3	4	5	6	7	8	9
10	0.0000	0.0004	0.0008	0.0012	0.0016	0.0020	0.0024	0.0028	0.0032	0.0036
11	0.0043	0.0047	0.0051	0.0055	0.0059	0.0063	0.0067	0.0071	0.0075	0.0079
12	0.0083	0.0087	0.0091	0.0095	0.0099	0.0103	0.0107	0.0111	0.0115	0.0119
13	0.0123	0.0127	0.0131	0.0135	0.0139	0.0143	0.0147	0.0151	0.0155	0.0159
14	0.0163	0.0167	0.0171	0.0175	0.0179	0.0183	0.0187	0.0191	0.0195	0.0199
15	0.0203	0.0207	0.0211	0.0215	0.0219	0.0223	0.0227	0.0231	0.0235	0.0239
16	0.0243	0.0247	0.0251	0.0255	0.0259	0.0263	0.0267	0.0271	0.0275	0.0279
17	0.0283	0.0287	0.0291	0.0295	0.0299	0.0303	0.0307	0.0311	0.0315	0.0319
18	0.0323	0.0327	0.0331	0.0335	0.0339	0.0343	0.0347	0.0351	0.0355	0.0359
19	0.0363	0.0367	0.0371	0.0375	0.0379	0.0383	0.0387	0.0391	0.0395	0.0399
20	0.0403	0.0407	0.0411	0.0415	0.0419	0.0423	0.0427	0.0431	0.0435	0.0439
21	0.0443	0.0447	0.0451	0.0455	0.0459	0.0463	0.0467	0.0471	0.0475	0.0479
22	0.0483	0.0487	0.0491	0.0495	0.0499	0.0503	0.0507	0.0511	0.0515	0.0519
23	0.0523	0.0527	0.0531	0.0535	0.0539	0.0543	0.0547	0.0551	0.0555	0.0559
24	0.0563	0.0567	0.0571	0.0575	0.0579	0.0583	0.0587	0.0591	0.0595	0.0599
25	0.0603	0.0607	0.0611	0.0615	0.0619	0.0623	0.0627	0.0631	0.0635	0.0639
26	0.0643	0.0647	0.0651	0.0655	0.0659	0.0663	0.0667	0.0671	0.0675	0.0679
27	0.0683	0.0687	0.0691	0.0695	0.0699	0.0703	0.0707	0.0711	0.0715	0.0719
28	0.0723	0.0727	0.0731	0.0735	0.0739	0.0743	0.0747	0.0751	0.0755	0.0759
29	0.0763	0.0767	0.0771	0.0775	0.0779	0.0783	0.0787	0.0791	0.0795	0.0799
30	0.0803	0.0807	0.0811	0.0815	0.0819	0.0823	0.0827	0.0831	0.0835	0.0839
31	0.0843	0.0847	0.0851	0.0855	0.0859	0.0863	0.0867	0.0871	0.0875	0.0879
32	0.0883	0.0887	0.0891	0.0895	0.0899	0.0903	0.0907	0.0911	0.0915	0.0919
33	0.0923	0.0927	0.0931	0.0935	0.0939	0.0943	0.0947	0.0951	0.0955	0.0959
34	0.0963	0.0967	0.0971	0.0975	0.0979	0.0983	0.0987	0.0991	0.0995	0.0999
35	0.1003	0.1007	0.1011	0.1015	0.1019	0.1023	0.1027	0.1031	0.1035	0.1039
36	0.1043	0.1047	0.1051	0.1055	0.1059	0.1063	0.1067	0.1071	0.1075	0.1079
37	0.1083	0.1087	0.1091	0.1095	0.1099	0.1103	0.1107	0.1111	0.1115	0.1119
38	0.1123	0.1127	0.1131	0.1135	0.1139	0.1143	0.1147	0.1151	0.1155	0.1159
39	0.1163	0.1167	0.1171	0.1175	0.1179	0.1183	0.1187	0.1191	0.1195	0.1199
40	0.1203	0.1207	0.1211	0.1215	0.1219	0.1223	0.1227	0.1231	0.1235	0.1239

COMMON LOGARITHMS (continued).

	0	1	2	3	4	5	6	7	8	9
110	0.0413	0.0417	0.0421	0.0425	0.0429	0.0433	0.0437	0.0441	0.0445	0.0449
111	0.0453	0.0457	0.0461	0.0465	0.0469	0.0473	0.0477	0.0481	0.0485	0.0489
112	0.0493	0.0497	0.0501	0.0505	0.0509	0.0513	0.0517	0.0521	0.0525	0.0529
113	0.0533	0.0537	0.0541	0.0545	0.0549	0.0553	0.0557	0.0561	0.0565	0.0569
114	0.0573	0.0577	0.0581	0.0585	0.0589	0.0593	0.0597	0.0601	0.0605	0.0609
115	0.0613	0.0617	0.0621	0.0625	0.0629	0.0633	0.0637	0.0641	0.0645	0.0649
116	0.0653	0.0657	0.0661	0.0665	0.0669	0.0673	0.0677	0.0681	0.0685	0.0689
117	0.0693	0.0697	0.0701	0.0705	0.0709	0.0713	0.0717	0.0721	0.0725	0.0729
118	0.0733	0.0737	0.0741	0.0745	0.0749	0.0753	0.0757	0.0761	0.0765	0.0769
119	0.0773	0.0777	0.0781	0.0785	0.0789	0.0793	0.0797	0.0801	0.0805	0.0809
120	0.0813	0.0817	0.0821	0.0825	0.0829	0.0833	0.0837	0.0841	0.0845	0.0849
121	0.0853	0.0857	0.0861	0.0865	0.0869	0.0873	0.0877	0.0881	0.0885	0.0889
122	0.0893	0.0897	0.0901	0.0905	0.0909	0.0913	0.0917	0.0921	0.0925	0.0929
123	0.0933	0.0937	0.0941	0.0945	0.0949	0.0953	0.0957	0.0961	0.0965	0.0969
124	0.0973	0.0977	0.0981	0.0985	0.0989	0.0993	0.0997	0.1001	0.1005	0.1009
125	0.1013	0.1017	0.1021	0.1025	0.1029	0.1033	0.1037	0.1041	0.1045	0.1049
126	0.1053	0.1057	0.1061	0.1065	0.1069	0.1073	0.1077	0.1081	0.1085	0.1089
127	0.1093	0.1097	0.1101	0.1105	0.1109	0.1113	0.1117	0.1121	0.1125	0.1129
128	0.1133	0.1137	0.1141	0.1145	0.1149	0.1153	0.1157	0.1161	0.1165	0.1169
129	0.1173	0.1177	0.1181	0.1185	0.1189	0.1193	0.1197	0.1201	0.1205	0.1209

LOGARITHMIC TABLES

11

COMMON LOGARITHM (cont. of p. 10)

	0	1	2	3	4	5	6	7	8	9
130	11291	11128	11013	10894	10771	10645	10516	10384	10249	10112
131	10974	10836	10695	10551	10404	10254	10101	9945	9786	9624
132	9460	9294	9125	8953	8778	8600	8419	8235	8048	7858
133	7665	7469	7270	7068	6863	6655	6444	6230	6013	5793
134	5570	5354	5134	4911	4685	4456	4224	3989	3751	3510
135	3267	3021	2772	2520	2265	2007	1747	1484	1218	950
136	680	401	119	-164	-432	-695	-953	-1205	-1452	-1694
137	-1931	-2168	-2400	-2627	-2849	-3066	-3278	-3484	-3685	-3881
138	-4073	-4260	-4442	-4619	-4791	-4958	-5120	-5277	-5429	-5576
139	-5718	-5865	-6007	-6144	-6276	-6403	-6525	-6642	-6754	-6861
140	-6964	-7061	-7153	-7240	-7322	-7400	-7473	-7541	-7604	-7662
141	-7715	-7773	-7826	-7884	-7937	-7985	-8028	-8076	-8119	-8167
142	-8209	-8252	-8295	-8338	-8376	-8419	-8462	-8500	-8538	-8576
143	-8613	-8650	-8687	-8724	-8761	-8798	-8835	-8872	-8909	-8946
144	-8983	-9019	-9056	-9093	-9129	-9166	-9203	-9239	-9276	-9313
145	-9349	-9386	-9423	-9459	-9496	-9533	-9569	-9606	-9643	-9679
146	-9716	-9753	-9789	-9826	-9863	-9899	-9936	-9973	-10000	

COMMON LOGARITHM (cont. of p. 10)

	0	1	2	3	4	5	6	7	8	9
150	17609	17608	17607	17606	17605	17604	17603	17602	17601	17600
151	17599	17598	17597	17596	17595	17594	17593	17592	17591	17590
152	17589	17588	17587	17586	17585	17584	17583	17582	17581	17580
153	17579	17578	17577	17576	17575	17574	17573	17572	17571	17570
154	17569	17568	17567	17566	17565	17564	17563	17562	17561	17560
155	17559	17558	17557	17556	17555	17554	17553	17552	17551	17550
156	17549	17548	17547	17546	17545	17544	17543	17542	17541	17540
157	17539	17538	17537	17536	17535	17534	17533	17532	17531	17530
158	17529	17528	17527	17526	17525	17524	17523	17522	17521	17520
159	17519	17518	17517	17516	17515	17514	17513	17512	17511	17510
160	17509	17508	17507	17506	17505	17504	17503	17502	17501	17500
161	17499	17498	17497	17496	17495	17494	17493	17492	17491	17490
162	17489	17488	17487	17486	17485	17484	17483	17482	17481	17480
163	17479	17478	17477	17476	17475	17474	17473	17472	17471	17470
164	17469	17468	17467	17466	17465	17464	17463	17462	17461	17460
165	17459	17458	17457	17456	17455	17454	17453	17452	17451	17450
166	17449	17448	17447	17446	17445	17444	17443	17442	17441	17440
167	17439	17438	17437	17436	17435	17434	17433	17432	17431	17430
168	17429	17428	17427	17426	17425	17424	17423	17422	17421	17420
169	17419	17418	17417	17416	17415	17414	17413	17412	17411	17410

b

LOGARITHMIC TABLES.

COMMON LOGARITHMS (continued).

	0	1	2	3	4	5	6	7	8	9	1 2 3	4 5 6	7 8 9
170	23015	23070	23126	23181	23237	23292	23348	23403	23459	23514	3 5 8	10 13 15	18 20 22
171	23569	23625	23680	23736	23791	23846	23902	23957	24012	24068	3 5 8	10 13 15	18 20 22
172	24123	24179	24234	24289	24345	24400	24455	24510	24565	24620	3 5 8	10 13 15	18 20 22
173	24675	24730	24785	24840	24895	24950	25005	25060	25115	25170	3 5 8	10 13 15	18 20 22
174	25225	25280	25335	25390	25445	25500	25555	25610	25665	25720	3 5 8	10 13 15	18 20 22
175	25775	25830	25885	25940	25995	26050	26105	26160	26215	26270	3 5 8	10 13 15	18 20 22
176	26325	26380	26435	26490	26545	26600	26655	26710	26765	26820	3 5 8	10 13 15	18 20 22
177	26875	26930	26985	27040	27095	27150	27205	27260	27315	27370	3 5 8	10 13 15	18 20 22
178	27425	27480	27535	27590	27645	27700	27755	27810	27865	27920	3 5 8	10 13 15	18 20 22
179	27975	28030	28085	28140	28195	28250	28305	28360	28415	28470	3 5 8	10 13 15	18 20 22
180	28525	28580	28635	28690	28745	28800	28855	28910	28965	29020	3 5 8	10 13 15	18 20 22
181	29075	29130	29185	29240	29295	29350	29405	29460	29515	29570	3 5 8	10 13 15	18 20 22
182	29625	29680	29735	29790	29845	29900	29955	30010	30065	30120	3 5 8	10 13 15	18 20 22
183	30175	30230	30285	30340	30395	30450	30505	30560	30615	30670	3 5 8	10 13 15	18 20 22
184	30725	30780	30835	30890	30945	31000	31055	31110	31165	31220	3 5 8	10 13 15	18 20 22
185	31275	31330	31385	31440	31495	31550	31605	31660	31715	31770	3 5 8	10 13 15	18 20 22
186	31825	31880	31935	31990	32045	32100	32155	32210	32265	32320	3 5 8	10 13 15	18 20 22
187	32375	32430	32485	32540	32595	32650	32705	32760	32815	32870	3 5 8	10 13 15	18 20 22
188	32925	32980	33035	33090	33145	33200	33255	33310	33365	33420	3 5 8	10 13 15	18 20 22
189	33475	33530	33585	33640	33695	33750	33805	33860	33915	33970	3 5 8	10 13 15	18 20 22
190	34025	34080	34135	34190	34245	34300	34355	34410	34465	34520	3 5 8	10 13 15	18 20 22

COMMON LOGARITHMS (continued).

	0	1	2	3	4	5	6	7	8	9	1 2 3	4 5 6	7 8 9
196	27875	27930	27985	28040	28095	28150	28205	28260	28315	28370	3 5 8	10 13 15	16 18 21
197	28425	28480	28535	28590	28645	28700	28755	28810	28865	28920	3 5 8	10 13 15	16 18 21
198	28975	29030	29085	29140	29195	29250	29305	29360	29415	29470	3 5 8	10 13 15	16 18 21
199	29525	29580	29635	29690	29745	29800	29855	29910	29965	30020	3 5 8	10 13 15	16 18 21
200	30075	30130	30185	30240	30295	30350	30405	30460	30515	30570	3 5 8	10 13 15	16 18 21
201	30625	30680	30735	30790	30845	30900	30955	31010	31065	31120	3 5 8	10 13 15	16 18 21
202	31175	31230	31285	31340	31395	31450	31505	31560	31615	31670	3 5 8	10 13 15	16 18 21
203	31725	31780	31835	31890	31945	32000	32055	32110	32165	32220	3 5 8	10 13 15	16 18 21
204	32275	32330	32385	32440	32495	32550	32605	32660	32715	32770	3 5 8	10 13 15	16 18 21
205	32825	32880	32935	32990	33045	33100	33155	33210	33265	33320	3 5 8	10 13 15	16 18 21
206	33375	33430	33485	33540	33595	33650	33705	33760	33815	33870	3 5 8	10 13 15	16 18 21
207	33925	33980	34035	34090	34145	34200	34255	34310	34365	34420	3 5 8	10 13 15	16 18 21
208	34475	34530	34585	34640	34695	34750	34805	34860	34915	34970	3 5 8	10 13 15	16 18 21
209	35025	35080	35135	35190	35245	35300	35355	35410	35465	35520	3 5 8	10 13 15	16 18 21
210	35575	35630	35685	35740	35795	35850	35905	35960	36015	36070	3 5 8	10 13 15	16 18 21

Base of Common Logarithm = 10.

Hyp. Log. $x = \frac{1}{M} \text{ Com. Log. } x$

Base of Hyperbolic Logarithms = 2.71828.

Hyp. Log $x = M \text{ Hyp. Log. } z$

Number.	Com. Log.	Number.	Com. Log.
e. 2.71828	0.434 2945	π 3.14159	0.499 1439
$\frac{1}{M}$.36059	0.362 2167	$\frac{1}{e}$.367 8798	1.389 5680
M 0.434 294	1.365 7843	$\frac{1}{\pi}$ 0.318 309	1.718 9386
		$\frac{1}{e^2}$.135 348	0.218 6749

DENSITIES OF GASES.

DENSITIES OF GASES.

(The observed densities are given in this Table.)

Name of Gas.	Formula	Molecular Weight	Weight of 1 liter at 0° C. and 760 mm. bar.	Logarithm	Observer.
Acetylene.	C_2H_2	26.04	0.9813	0.075187	Berthelot
Amyloma.	NH_3	17.034	0.768	1.8863417	Perrin & Dumas
Atmospheric air.	...	...	1.2928	0.1115313	Rayleigh
Carbon monoxide.	CO	28	1.259	0.070199	"
Carbon dioxide.	CO_2	44	1.977	0.2952857	"
Chlorine.	Cl_2	70.9	3.494	0.5475005	Townsend
Ethylene.	C_2H_4	28.05	0.9807	0.106671	Sussner
Hydrogen.	H_2	2	0.0899	2.9557397	Hayden
Hydrogen chloride.	HCl	36.465	1.492	0.2036719	Gay and Burt
Hydrogen sulphide.	H_2S	34.08	1.189	0.078809	Leduc
Methane.	CH_4	16.04	0.717	0.35855	Thomson
Nitrogen.	N_2	28.02	1.2507	0.071351	Rayleigh, Gray
Nitrous oxide.	N_2O	44.02	1.974	0.2961961	Rayleigh
Nitric oxide.	NO	30.01	1.343	0.1271996	Gay
Nitrous oxide.	N_2O	44.02	1.974	0.2961961	"
Oxygen.	O_2	32	1.429	0.15335	Rayleigh
Sulphur dioxide.	SO_2	64.07	3.266	0.563631	Leduc and others

Note.—1.35 gram of hydrogen occupies 1 cubic liter at N.T.P. * Corrected to 1900 cubic centimetre at 0° C. and 760 mm. bar.

Abbreviations used in this table at N.T.P. are given in § 2 (Remain).

TABLE OF FREEZING MIXTURES.

A mixture composed by weight	Temperature produced
Snow or broken ice, 2; common salt, 1	-18° C.
" " " 3; calcium chloride (cryst.), 1	-45 " "
Sodium sulphate (cryst.), 8; sulphuric acid, 1	-8 " "
" phosphate (cryst.), 9; nitric acid, 1	-26 " "
Ammonium nitrate, 1; water, 9	-16 " "
Ammonium chloride, 5; salt-petre, 5; sodium sulphate, 8; water, 16	-20 " "

Note.—The solids used should be finely powdered.

MELTING POINTS OF METALS

MELTING-POINTS OF METALS.

Metal	Melting Point	Observer
Aluminium	657	Holborn and Day
Antimony	630	"
Bismuth	269	Caldwell
Cadmium	321	Holborn and Day
Chromium	1920	Paterson and Stansfeld
Cobalt	1485	"
Copper	1082	Holborn and Day
Gold	1063	"
Cast iron	1130	Holborn
Lead	327	Holborn and Day
Lithium	180	Bernini and Canton
Magnesium	633	Heycock and Neville
Manganese	1260	Paterson and Stansfeld
Mercury (B.P. 356°)	37.8	Croppers
Molybdenum	2450	Pratt and Meyer
Nickel	1432	Paterson and Wallingford
Osmium	2700	"
Platinum	1750	Various
Potassium	62.5	Holt and Sims
Silver	961	Holborn and Day
Sodium	97.6	Bernini and Canton
Tin	232	Heycock and Neville
Tungsten	3250	Langmuir
Zinc	419	Day and Spelman

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS.

Element	Compound	Factor	Logarithm
ALUMINIUM (Al = 27.10)			
Al	Al_2O_3 (anhydrous)	0.53933	1.73155
"	" (hydrated)	0.87499	0.94181
"	" (hydrated)	1.20000	0.07918
"	$\text{Al}_2(\text{PO}_4)_3$	0.41837	1.62156
"	$\text{Al}_2(\text{SO}_4)_3$	0.71271	0.55269
"	Ammonium alum (hydrated)	1.04641	0.01971
ANTIMONY (Sb = 120.07)			
Sb	Sb_2O_3 (anhydrous)	0.78975	1.89749
"	Sb_2S_3	0.71121	1.85185
"	"	0.90110	1.95456
ARSENIC (As = 74.96)			
As	$2\text{NH}_4\text{MeAsO}_4 \cdot \text{H}_2\text{O}$ (anhydrous)	0.39584	1.59832
"	"	0.51994	1.71595
"	"	0.60409	1.78104
"	$\text{Me}_2\text{As}_2\text{O}_7$	0.48271	1.68371
"	"	0.63736	1.80434
"	"	0.74034	1.86943
"	As_2O_3	0.75748	1.87937
"	As_2S_3	0.60918	1.78475
"	"	0.80123	1.90554
"	"	0.93425	1.97047

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS *continued*.

Element.	To convert	Factor.	Logarithm (to be added)
Barium (Ba = 137.37)			
Ba	BaSO ₄ into Ba	0.58846	1.769 72
"	" " BaO	0.65700	1.817 57
"	" " BaCO ₃	0.84548	1.927 41
"	" " BaCl ₂	0.89226	1.950 49
"	" " BaCl ₂ 2H ₂ O	1.07662	0.049 79
"	" " S	0.13731	1.137 81
"	" " SO ₂	0.34560	1.535 26
"	" " SO ₃	0.41154	1.614 41
"	" " H ₂ SO ₄	0.42018	1.623 41
"	" " CaSO ₄	0.58319	1.765 81
"	" " CaSO ₄ 2H ₂ O	0.73754	1.867 79
"	" " FeSO ₄ 7H ₂ O	1.19100	0.075 90
"	" " PbSO ₄	1.29920	0.113 67
"	" " MgSO ₄	0.51572	1.712 42
"	" " K ₂ SO ₄	0.71653	1.853 05
"	" " Na ₂ SO ₄	0.60859	1.784 33
"	" " Na ₂ SO ₄ 10H ₂ O	1.38035	0.139 99
"	" " (NH ₄) ₂ SO ₄	0.56612	1.752 89
"	2BaSO ₄ " FeS ₂	6.25698	1.109 85
"	4BaSO ₄ " Al ₂ (NH ₄) ₂ (SO ₄) ₃ 24H ₂ O	0.97129	1.987 35
"	BaCO ₃ " $\frac{1}{2}$ Ba	0.69600	1.842 61
"	" " BaO	0.77707	1.890 16
"	" " CO ₂	0.30400	1.482 87
Bismuth (Bi = 208)			
Bi	Bi ₂ O ₃ into Bi	0.89655	1.952 58
"	Bi ₂ S ₃ " Bi	0.81222	1.909 67

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS.—continued

Element	To convert		Factor	Logarithm to be applied
BORON (B) 10.8				
B	B ₂ O ₃	not	B	0.51232
"	B ₂ O ₃	"	2H BO ₂	1.77137
"	2H BO	"	B ₂ O ₃	0.56359
CARBON (C) 12.0				
C	C ₂ H ₄	"	C	0.87529
"	C ₂ H ₆	"	C	0.77861
"	"	"	CO	0.88877
CALCIUM (Ca) 40.07				
Ca	CaO	"	Ca	0.71467
"	"	"	CaCl ₂	1.78173
"	"	"	CaSO ₄	2.42804
"	"	"	CaSO ₄ · 2H ₂ O	3.07950
"	"	"	CaCl	1.97849
"	"	"	CaH ₂ O ₂	1.32131
"	3CaO	"	Ca ₃ P ₂ O ₇	1.81166
"	CaCl ₂	"	CaO	0.50518
"	"	"	Cl ₂	0.60897
"	CaCO ₃	"	Ca	0.40012
"	"	"	CaO	0.56031
"	"	"	CO ₂	0.43969
"	"	"	C ₂	0.79958
"	"	"	Ca ₂ O ₃	1.36010
"	"	"	CaSO ₄ · 2H ₂ O	1.72040
"	CaSO ₄	"	Ca	0.29433
"	"	"	CaO	0.41186
"	"	"	CaCO ₃	0.73505

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS. *continued.*

Element.	Transformed into.	Factor.	Logarithm (to be added)		
CHLORINE (Cl = 35.46)					
Cl	CaCl ₂	1.26467	0.101498		
"	"	1.58844	0.200418		
"	CaF ₂	0.53860	0.800423		
"	"	0.73672	0.877779		
"	"	0.45789	0.660777		
"	"	0.56687	0.351418		
"	CuCl ₂	1.12000	0.149227		
CHLORINE (Cl = 35.46)					
"	FeCl ₃	0.27277	0.435773		
"	"	1.26632	0.300830		
"	"	2.06915	0.381885		
"	"	1.90927	0.280887		
"	"	PbCl ₂	0.67045	0.783322	
"	2HCl	MnO ₂	0.98784	1.99469	
"	C ₂ H ₆ O	C ₂ H ₄ O ₂	1.36368	0.115417	
CHLORINE (Cl = 35.46)					
Cl	Cl ₂	HCl	1.62843	0.012487	
"	"	"	NaCl	1.64862	0.217412
"	"	"	KCl	2.10265	0.322777
"	Cl ₂	"	MgCl ₂	1.34282	0.12805
"	"	"	CaCl ₂	1.56709	0.19452
"	"	"	"	0.22560	1.35335
CHROMIUM (Cr = 52)					
Cr	Cr ₂ O ₃	into	Cr ₂	0.68421	1.83549
"	"	"	K ₂ Cr ₂ O ₇	1.93553	0.28680
COBALT (Co = 58.97)					
Co	CoO	into	Co	0.78658	1.89574

FACTORS AND THEIR LOGARITHMS REQUIRED FOR
GRAVIMETRIC ANALYSIS *continued*

Element	Compound	Factor	Logarithm	
Calcium $\text{Ca} = 40.078$				
Ca	Ca	1.27176	0.10359	
"	CaO	1.47132	0.16803	
"	2CaO	1.94264	0.28798	
"	CaCO_3	1.44478	0.15702	
"	CaSO_4	1.52256	0.18141	
Calcium Chloride $\text{CaCl}_2 = 110.98$				
Ca	Ca	1.27176	0.10359	
"	Cl	0.74276	0.07045	
Hydrogen Chloride $\text{HCl} = 36.46$				
H	HCl	0.97259	0.08783	
"	HNO_3	N	0.22132	0.04035
"	"	N + O	1.34178	0.09991
"	2HNO_3	N + O	0.85365	0.03091
"	H_2SO_4	(NH $_4$) 2SO_4	1.24700	0.14178
"	"	2HCl	0.74559	0.07155
"	"	SO_2	0.84633	0.09180
"	$2\text{H}_2\text{O}_2$	($\text{H}_2\text{O} + \text{H}_2\text{O}_2$)	1.31995	0.14957
Iron $\text{Fe} = 55.847$				
Fe	Fe	1.28655	0.10942	
"	"	FeCO_3	2.07450	0.31395
"	"	FeS	2.14830	0.33209
"	"	$\text{SO}_2 + \text{H}_2\text{O}$	1.97890	0.09742
"	Fe_2O_3	Fe_2O_3	1.42980	0.15528
"	"	$\text{Fe}_2\text{O}_3 + \text{H}_2\text{O}$	1.59112	0.20179
"	"	$\text{Fe}_2\text{O}_3 + 3\text{H}_2\text{O}$	1.91315	0.28139

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS—continued.

Element.	To convert		Factor.	Logarithm (to be added).
IRON (Fe=55.84)—continued.				
Fe	Fe ₂	into Fe ₂ (PO ₄) ₂	2.70200	0.431 69
"	"	" MnO ₂	0.77838	1.891 19
"	Fe ₂ O ₃	" Fe ₂	0.69940	1.841 72
"	"	" Fe ₂ (PO ₄) ₂	1.88978	0.276 41
"	3Fe ₂ O ₃	" 2Fe ₂ O ₄	0.96660	1.985 25
"	FeS	" Fe	0.63520	1.802 91
"	2FeS	" Fe ₂ O ₃	0.90820	1.958 18
"	FeS ₂	" S ₂	0.53452	1.727 96
"	2{Fe(NH ₄) ₂ (SO ₄) ₂ ·6H ₂ O}	into MnO ₂	6.11083	1.044 68
LEAD (Pb=207.2)				
Pb	Pb	into PbO	1.07724	0.032 30
"	PbS	" Pb	0.86597	1.937 50
"	"	" PbO	0.93281	1.969 81
"	3PbO	" 2PbCO ₃ , Pb(OH) ₂	1.15833	0.063 83
"	PbO ₂	" Pb	0.86622	1.937 53
"	PbSO ₄	" Pb	0.68322	1.834 56
"	"	" PbO	0.73597	1.866 86
"	"	" PbS	0.78807	1.897 06
"	PbCrO ₄	" Pb	0.64109	1.806 92
"	"	" PbO	0.69059	1.839 22
"	"	" PbSO ₄	0.93834	1.972 36
"	2PbCrO ₄	" Cr ₂ O ₃	0.23515	1.371 34
"	"	" K ₂ Cr ₂ O ₇	0.45514	1.658 14
"	3PbCrO ₄	" 2PbCO ₃ , Pb(OH) ₂	0.79993	1.903 05

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS—continued.

Element.	To convert		Factor.	Logarithm (to be added).
MAGNESIUM ($Mg = 24.32$)				
Mg	MgCl ₂	into MgO	0.42329	1.626 70
"	"	" Cl ₂	0.74464	1.871 95
"	MgO	" MgCl ₂	2.09127	0.320 41
"	"	" MgCl ₂	2.36210	0.373 30
"	"	" MgSO ₄	2.98586	0.475 07
"	"	" MgSO ₄ · 7H ₂ O	6.11364	0.786 30
"	"	" Mg(NO ₃) ₂	3.67907	0.565 74
"	Mg ₂ P ₂ O ₇	" Mg ₂ O	0.21839	1.339 23
"	"	" 2MgO	*0.36207	1.558 79
"	"	" 2MgCO ₃	0.75718	1.879 20
"	"	" 2MgCl ₂	0.85524	1.932 09
"	"	" 2MgSO ₄	1.08109	0.033 86
"	"	" 2(MgSO ₄ · 7H ₂ O)	2.21356	0.345 09
"	"	" P ₂ O ₅	0.27874	1.445 19
"	"	" P ₂ O ₅	0.63793	1.804 77
"	"	" 2H ₃ PO ₄	0.88060	1.944 78
"	"	" CaH ₂ (PO ₄) ₂	1.05116	0.021 79
"	"	" Ca(PO ₃) ₂	0.88568	1.949 23
"	"	" Ca ₂ (PO ₄) ₂	1.39318	0.144 01
"	MgSO ₄	" Mg	0.20201	1.305 37
"	"	" MgO	0.33491	1.524 93
MANGANESE ($Mn = 54.93$)				
Mn	Mn	into MnO	1.29128	0.111 02
"	MnO	" Mn	0.77442	1.888 98
"	MnO ₂	" Mn	0.63189	1.800 64

* Or use the Phosphate Table, pp. 130-137, subtracting from the Mg₂P₂O₇ found the P₂O₅ in it.

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS --continued.

Element.	To convert	Factor.	Logarithm (to be added).
MANGANESE (Mn = 54.93) -contd.			
Mn	Mn_3O_4 into 3Mn	0.72027	1.857 49
"	" " " 3MnO	0.93007	1.968 51
"	MnS " Mn	0.63138	1.800 29
"	" " " MnO	0.81529	1.911 31
"	MnSO_4 " Mn	0.36377	1.560 83
"	" " " MnO	0.46974	1.671 85
MERCURY (Hg = 200.6)			
Hg	HgS into Hg	0.86217	1.935 59
"	" " " HgO	0.93093	1.968 92
"	Hg_2Cl_2 " 2Hg	0.84978	1.929 31
"	" " " Hg_2O	0.88367	1.946 29
MOLYBDENUM			
Mo	Ammonium phospho-molybdate (dried at 100° C.) into P	0.0163	2.212 19
"	" " " P_2O_5	0.0373	2.571 77
"	" " " into $\text{Ca}_3(\text{PO}_4)_2$	0.08147	2.911 60
NICKEL (Ni = 58.68)			
Ni	NiO into Ni	0.78575	1.895 29
NITROGEN (14.01) AND AMMONIUM (18.042)			
N	N into N_2	1.21585	0.084 88
"	" " " HNO_3	4.49807	0.653 03
"	" " " NaNO_3	0.06780	0.783 03
"	" " " KNO_3	7.21700	0.858 36
"	" " " Albuminoids	6.25	0.795 88
"	" " " Caffeine	3.46395	0.539 57

FACTORS AND THEIR LOGARITHMS REQUIRED ON
GRAVIMETRIC ANALYSIS—continued.

Element.	To convert		Factor.	Logarithm (to be added).
NITROGEN (14.01) AND AMMONIUM (18.042)—continued.				
N	N ₂	into (NH ₄) ₂ SO ₄	4.71642	0.673 61
"	"	" N ₂ O	3.85510	0.586 04
"	N ₂ O ₅	" N ₂	0.25940	1.413 96
"	"	" 2NaNO ₃	1.57397	0.197 00
"	"	" 2KNO ₃	1.87206	0.272 32
"	"	" Ca(NO ₃) ₂	1.51907	0.181 58
"	"	" Mg(NO ₃) ₂	1.37326	0.137 75
"	NH ₃	" N	0.82247	1.915 12
"	"	" NH ₄ Cl	3.14090	0.497 05
"	2NH ₃	" (NH ₄) ₂ SO ₄	3.87912	0.588 73
"	NH ₄ Cl	" N	0.26186	1.418 07
"	"	" NH ₃	0.31838	1.502 95
"	(NH ₄) ₂ SO ₄	" N ₂	0.21202	1.326 39
"	"	" 2NH ₃	0.25779	1.411 27
"	"	" H ₂ SO ₄	0.74221	1.870 53
PHOSPHORUS (P=31.01)				
P	P ₂	into P ₂ O ₅	2.28866	0.359 58
"	P ₂ O ₅	" P ₂	0.43694	1.640 42
"	"	" Ca ₃ (PO ₄) ₂	2.18391	0.339 23
"	"	" CaH ₄ (PO ₃) ₂	1.64824	0.217 02
PLATINUM (Pt=195.2)				
Pt	(NH ₄) ₂ PtCl ₆	into N ₂	0.06310	2.800 04
"	"	" 2NH ₃	0.07672	2.884 92
"	"	" 2NH ₄ Cl	0.24098	1.381 97
"	"	" (NH ₄) ₂ SO ₄	0.29761	1.473 69

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS—*continued*.

Element.	To convert		Factor.	Logarithm (to be added).
	PLATINUM (Pt = 195.2)— <i>contd.</i>			
Pt	K_2PtCl_6	into K_2O	0.16085	$\bar{1}.206\ 43$
"	"	" 2KCl	0.30673	$\bar{1}.486\ 76$
"	"	" K_2O	0.19376	$\bar{1}.287\ 27$
"	"	" K_2SO_4	0.35846	$\bar{1}.551\ 14$
"	Pt	" $2\text{NH}_4\text{Cl}$	0.54818	$\bar{1}.738\ 92$
"	"	" $(\text{NH}_4)_2\text{SO}_4$	0.67702	$\bar{1}.830\ 60$
	POTASSIUM (K = 39.1)			
K	K	into KCl	1.90690	0.280 33
"	K_2	" K_2O	1.20160	0.080 84
"	KCl	" Cl	0.47559	$\bar{1}.677\ 23$
"	"	" $\text{KHC}_4\text{H}_4\text{O}_6$	2.52320	0.401 95
"	2KCl	" K_2O	0.63171	$\bar{1}.800\ 52$
"	"	" K_2SO_4	1.16866	0.067 69
"	KClO_4	" KCl	0.5381†	$\bar{1}.730\ 87$
"	2KClO_4	" K_2O	0.3100†	$\bar{1}.531\ 44$
"	"	" K_2SO_4	0.62887†	$\bar{1}.798\ 56$

* International methods of determining potash were adopted at the International Congress of Applied Chemistry held at Berlin, 1903 (see *Chemical News*, No. 2615, Feb. 4, 1910). The platinumchloride pp.[†] is to be dried at 120–130° C., weighed warm, and the following factors (which are based on Berzelius's atomic weight Pt = 197.2) used:—

$$\text{K}_2\text{PtCl}_6 \times 0.30568 = \text{KCl} \quad (\log. \bar{1}.48515)$$

$$\text{ " } \times 0.19305 = \text{K}_2\text{O} \quad (\log. \bar{1}.28567)$$

$$\text{ " } \times 0.35714 = \text{K}_2\text{SO}_4 \quad (\log. \bar{1}.55284)$$

† These are the factors used in connection with the International perchloric acid method for determining potash (see note above).

‡ Also reprinted in pamphlet form.

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS—*continued*.

Element.	To convert		Factor.	Logarithm (to be added).
POTASSIUM (K = 39.1) — <i>contd.</i>				
K	K ₂ O	into 2KCl	1.58301	0.199 49
"	"	" K ₂ SO ₄	1.85000	0.267 17
"	"	" 2KNO ₃	2.14671	0.331 77
"	"	" K ₂ CO ₃	1.46709	0.166 46
"	"	into 2{KNaC ₄ H ₄ O ₆ ·4H ₂ O}	5.99138	0.777 53
"	"	into 2KHC ₄ H ₄ O ₆	3.99427	0.601 44
"	"	" 2KOH	1.19125	0.076 00
"	2KOH	" K ₂ O	0.83945	T.924 00
"	K ₂ CO ₃	" K ₂ O	0.68162	T.833 54
"	K ₂ SO ₄	" K ₂ O	0.54054	T.732 83
"	"	" 2KCl	0.85568	T.932 31
"	KNO ₃	" N	0.13856	T.141 61
SILICON (Si = 28.3)				
Si	SiO ₂	into Si	0.46932	T.671 17
SILVER (Ag = 107.88)				
Ag	AgBr	into Br	0.42556	T.628 96
"	AgCl	" Ag	0.75262	T.876 57
"	"	" Cl	0.24738	T.393 37
"	"	" HCl	0.25442	T.405 54
"	"	" AgNO ₃	1.18522	0.073 80
"	AgI	" I	0.54055	T.732 83
SODIUM (Na = 23)				
Na	Na	into NaCl	2.54174	0.405 13
"	Na ₂	" Na ₂ O	1.34783	0.129 63
"	Na ₂ O	" 2NaCl	1.88580	0.275 50

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS—*continued*.

Element.	To convert		Factor.	Logarithm (to be added).
SODIUM (Na = 23)—continued.				
Na	Na_2O	into Na_2SO_4	2.29145	0.360 11
"	"	Na_2CO_3	1.70968	0.232 91
"	"	2NaNO_3	2.74226	0.438 11
"	"	2NaOH	1.29058	0.110 79
"	$\text{Na}_2\text{B}_4\text{O}_7$	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$	1.89365	0.277 30
"	NaCl	Cl	0.60657	1.782 88
"	"	NaHCO_3	1.43702	0.157 46
"	2NaCl	Na_2O	0.53028	1.721 50
"	"	Na_2CO_3	0.90660	1.957 12
"	Na_2CO_3	Na_2O	0.58491	1.767 09
"	NaNO_3	N	0.16180	1.216 97
"	2NaOH	Na_2O	0.77484	1.889 21
"	Na_2CO_3	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	2.69811	0.431 06
"	Na_2SO_4	Na_2O	0.32378	1.510 26
"	"	Na_2O	0.43640	1.639 89
STRONTIUM (Sr = 87.63)				
Sr	SrCO_3	into Sr	0.59358	1.773 48
"	SrSO_4	Sr	0.47703	1.678 54
SULPHUR (S = 32.06)				
S	SO_3	into S	0.40045	1.602 55
"	"	CaSO_4	1.70036	0.230 54
"	"	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	2.15040	0.332 52
"	"	H_2SO_4	1.22500	0.688 15
"	"	$(\text{NH}_4)_2\text{SO}_4$	1.65056	0.217 63

FACTORS AND THEIR LOGARITHMS REQUIRED IN
GRAVIMETRIC ANALYSIS—*continued*.

Element.	To convert		Factor	Logarithm (to be added).
SULPHUR (S = 32.06)— <i>continued</i> .				
S	SO ₃	into	K ₂ SO ₄	2.17660 0.337 78
"	"	"	Na ₂ SO ₄	1.77440 0.249 06
"	"	"	MgSO ₄	1.50360 0.177 14
TIN (Sn = 118.7)				
Sn	Sn	into	SnO ₂	1.26960 0.103 66
"	SnO ₂	"	Sn	0.78766 1.896 34
ZINC (Zn = 65.37)				
Zn	Zn	into	ZnO	1.24476 0.095 09
"	"	"	ZnS	1.19059 0.173 36
"	"	"	ZnCl ₂	2.08490 0.319 09
"	ZnO	"	Zn	0.80337 1.901 91
"	ZnS	"	Zn	0.67087 1.826 34

Example.—1.327 grams of a substance gave 0.8470 gram BaSO₄; to find the percentages of SO₃ and S present respectively.

Since 1.327 grams give 0.847 gram BaSO₄, 100 grams will give $\frac{0.847 \times 100}{1.327} = \frac{84.70}{1.327}$.

Taking logs. Log. 84.70 = 1.92788
 " 1.327 = 0.12287

(subtracting) 1.80504
Add log. (BaSO₄ into SO₃) 1.53529

 1.34030 = 21.89 per cent. SO₃.
Add log. (SO₃ into S) 1.66263

 0.91293 = 8.77 per cent. S.

Rule.—First find the weight of the pt. that 100 parts of substance would give, then add the log. of the factor to get percentage of substance sought.

VOLUMETRIC FACTORS.

Definition.—A **Normal Solution** of a reagent is one that contains in a litre that proportion of its molecular weight in grams which corresponds to 1.008 grams of $\frac{1}{2}$ atomic hydrogen or its equivalent.

Thus, a normal solution of hydrochloric acid contains 36.468 grams HCl per litre; and normal sulphuric acid 98.076
 $\frac{2}{2} = 49.038$ grams H_2SO_4 per litre. Potassium permanganate, $K_2Mn_2O_8$, in acid solution, yields 5 atoms of oxygen,

equivalent to 10 atoms of hydrogen; hence a normal solution of permanganate contains $\frac{316.06}{10} = 31.606$ grams per litre.

Normal alkali solutions are such that a given volume requires for neutralization an equal volume of a normal acid solution.

		grams		Logarithms
Normal H_2SO_4	1 c.c.	$= 0.049038 H_2SO_4$	.	2.690 53
	"	$= 0.048030 SO_3$	.	2.681 51
	"	$= 0.040030 SO_2$	.	2.602 39
Normal HCl	1 c.c.	$= 0.036468 HCl$	.	2.561 91
	"	$= 0.03546 Cl$	.	2.549 74
Normal HNO_3	1 c.c.	$= 0.063018 HNO_3$	.	2.799 46
	"	$= 0.06201 NO_2$	.	2.792 46
	"	$= 0.05101 N_2O_5$	.	2.732 47
Normal $H_2C_2O_4$	1 c.c.	$= 0.063024 H_2C_2O_4 \cdot 2H_2O$	.	2.799 51
	"	$= 0.045008 H_2C_2O_4$	.	2.653 29
Normal acid	1 c.c.	$= 0.01461 N$	.	2.146 44
	"	$= 0.017034 NH_3$	.	2.231 32
	"	$= 0.03505 NH_4OH$	.	2.544 69
	"	$= 0.1008 Na_2B_4O_7$	.	1.003 46
	"	$= 0.19088 Na_2B_4O_7 \cdot 10H_2O$	.	1.280 76

VOLUMETRIC FACTORS—*continued*.

	grams.	Logarithms.
Normal acid	1 c.c. = 0.028035 CaO	2.447 70
(<i>continued</i>).	„ = 0.037013 Ca(OH) ₂	2.568 71
	„ = 0.050035 CaCO ₃	2.699 27
	„ = 0.085693 Ba(OH) ₂	2.932 95
	„ = 0.157757 Ba(OH) ₂ , 8H ₂ O	1.197 99
	„ = 0.098635 BaCO ₃	2.994 25
	„ = 0.02616 MgO	2.304 49
	„ = 0.04216 MgCO ₃	2.624 90
	„ = 0.056108 KOH	2.749 02
	„ = 0.0691 K ₂ CO ₃	2.839 48
	„ = 0.18814 KHCO ₃ H ₂ O ₆	1.274 48
	„ = 0.108119 K ₂ C ₂ H ₃ O ₇ , H ₂ O	1.033 90
	„ = 0.098124 K ₂ C ₂ H ₃ O ₇	2.991 78
	„ = 0.141098 KNaC ₄ H ₄ O ₆ , 4H ₂ O	1.149 52
	„ = 0.040008 NaOH	2.602 15
	„ = 0.053 Na ₂ CO ₃	2.724 28
	„ = 0.14308 Na ₂ CO ₃ , 10H ₂ O	1.155 58
	„ = 0.084008 NaHCO ₃	2.924 32
Normal KOH	1 c.c. = 0.056108 KOH	2.749 02
	„ = 0.0471 K ₂ O	2.673 02
Normal NaOH	1 c.c. = 0.040008 NaOH	2.602 15
	„ = 0.031 Na ₂ O	2.491 36
Normal Na ₂ CO ₃	1 c.c. = 0.053 Na ₂ CO ₃	2.724 28
	„ = 0.030 Na ₂ O	2.477 12
	„ = 0.022 CO ₂	2.342 42
Normal alkali	1 c.c. = 0.060032 HC ₂ H ₃ O ₂	2.778 38
	„ = 0.0349 B ₂ O ₃	2.542 83
	„ = 0.061924 H ₂ B ₄ O ₇	2.791 86
	„ = 0.0504 Na ₂ B ₄ O ₇	2.702 43
	„ = 0.09511 Na ₂ B ₄ O ₇ , 10H ₂ O	2.979 73

VOLUMETRIC FACTORS—continued.

		grams.	Logarithms.
Normal alkali (continued).	1 c.c. =	0.070027 $\text{H}_2\text{C}_6\text{H}_4(\text{O})_2, \text{H}_2\text{O}$	2.845 27
	"	— 0.122048 benzoic acid	1.086 53
	"	— 0.088064 butyric "	2.944 80
	"	— 0.410432 cerotic "	1.613 21
	"	— 0.090048 lactic "	2.954 47
	"	— 0.067024 malic "	2.826 23
	"	— 0.282272 oleic "	1.450 67
	"	— 0.256256 palmitic "	1.408 67
	"	— 0.281288 stearic "	1.453 76
	"	— 0.075024 tartaric "	2.875 20
	"	— 0.18814 $\text{KH}_2\text{C}_4\text{H}_4\text{O}_6$	1.274 48
N 10 AgNO_3	1 c.c. =	0.010788 Ag	2.032 94
	"	— 0.016989 AgNO_3	2.230 17
	"	— 0.003546 Cl	3.549 74
	"	— 0.005816 NaCl	3.766 86
	"	— 0.0053502 NH_4Cl	3.728 37
	"	— 0.011902 KBr	2.075 62
	"	— 0.007156 KCl	3.872 51
	"	— 0.016602 KI	2.220 16
	"	— 0.010292 NaBr	2.012 50
	"	— 0.006199 Na_2HAsO_4	3.792 32
N 10 iodine	1 c.c. =	0.003203 SO_2	3.505 56
	"	— 0.0041038 H_2SO_3	3.613 19
	"	— 0.0126086 $\text{Na}_2\text{SO}_3, 7\text{H}_2\text{O}$	2.100 67
	"	— 0.0097146 $\text{K}_2\text{SO}_3, 2\text{H}_2\text{O}$	3.987 42
	"	— 0.02482 $\text{Na}_2\text{S}_2\text{O}_3, 5\text{H}_2\text{O}$	2.391 80
	"	— 0.004948 As_2O_3	3.694 13
N 10 Dichromate	1 c.c. =	0.005584 Fe	3.746 99
	"	— 0.007184 FeO	3.856 37
	"	— 0.011584 FeCO_3	2.063 86
	"	— 0.01519 FeSO_4	2.181 56
	"	— 0.0278012 $\text{FeSO}_4, 7\text{H}_2\text{O}$	3.444 06

VOLUMETRIC FACTORS—continued.

$\frac{N}{10}$	Thiosulphate	1 c.c. = $\frac{\text{grams}}{0.02482}$ $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$	Logarithms.
		"	2.394 80
		" = 0.012692 I	2.103 53
		" = 0.003546 Cl	3.549 74
		" = 0.007992 Br	3.902 66

CALCIUM (Ca = 40.07)

1 c.c. $\frac{N}{10}$	permanganate = 0.0028035 gram CaO	3.447 70
"	" = 0.0050035 gram CaO	3.699 27
"	" = 0.0086081 gram CaSO ₄	3.934 91
"	normal oxalic acid = 0.028035 gram CaO	2.447 70
"	Cryst. oxalic acid $\times 0.444 = \text{CaO}$	1.647 38
"	Ferrous ammonium sulphate $\times 0.07143 = \text{CaO}$	2.853 88

CHLORINE (Cl = 35.46)

1 c.c. $\frac{N}{10}$	silver solution = 0.003546 gram Cl	3.549 74
"	" = 0.005846 gram NaCl	3.766 86
1 c.c. $\frac{N}{10}$	arsenious or thiosulphate solution	
"	" = 0.003546 gram Cl	3.549 74

CHROMIUM (Cr = 52)

	Metallic iron $\times 0.3104 = \text{Cr}$	1.491 94
"	" $\times 0.5968 = \text{CrO}_3$	1.775 86
"	" $\times 0.8780 = \text{K}_2\text{Cr}_2\text{O}_7$	1.943 47
"	" $\times 1.929 = \text{PbCrO}_4$	0.285 40
	Ferrous ammonium sulphate $\times 0.0443 = \text{Cr}$	2.646 40
"	" $\times 0.0853 = \text{CrO}_3$	2.930 95
"	" $\times 0.1253 = \text{K}_2\text{Cr}_2\text{O}_7$	1.097 95
"	" $\times 0.2747 = \text{PbCrO}_4$	1.438 91
1 c.c. $\frac{N}{10}$	solution = 0.003333 gram CrO ₃	3.522 84
"	" = 0.004903 gram K ₂ Cr ₂ O ₇	3.690 45

VOLUMETRIC FACTORS—continued.

	Logarithms.
COPPER (Cu = 63.57)	
1 c.c. $\frac{N}{10}$ solution — 0.006357 gram Cu	3.803 25
Iron $\times 1.138$ = copper	0.056 14
Ferrous ammonium sulphate $\times 0.1622$ = copper	1.210 05
CYANOGEN (CN = 26.01)	
1 c.c. $\frac{N}{10}$ silver solution — 0.005202 gram CN	3.716 17.
„ „ „ 0.005401 gram HCN	3.732 72
„ „ „ 0.013022 gram KCN	2.114 68
„ $\frac{N}{10}$ iodine = 0.003255 gram KCN	3.512 55
POTASSIUM FERROCYANIDE (K₄Fe(Cy₆)₃ · 30H₂O = 422.348)	
Metallic iron $\times 7.563$ = cryst. potassium ferrocyanide	0.878 69
Ferrous ammonium sulphate $\times 1.080$ = cryst. potassium ferrocyanide	0.033 12
POTASSIUM FERRICYANIDE (K₃Fe₂(Cy₆)₃ = 658.4)	
Metallic iron $\times 5.895$ = potassium ferricyanide	0.770 48
Ferrous ammonium sulphate $\times 1.684$ = potassium ferricyanide	0.226 34
$\frac{N}{10}$ thiosulphate $\times 0.03292$ = potassium ferricyanide	2.517 46
GOLD (Au = 197.2)	
1 c.c. normal oxalic acid = 0.0657 gram gold	2.817 57
IODINE (I = 126.92)	
1 c.c. $\frac{N}{10}$ thiosulphate = 0.012692 gram iodine	2.103 53
IRON (Fe = 55.84)	
1 c.c. $\frac{N}{10}$ permanganate, dichromate, or thiosulphate	0.005584 Fe
„ „ „	0.007184 FeO
„ „ „	0.007984 Fe ₂ O ₃

VOLUMETRIC FACTORS—*continued*.

	Logarithms.
LEAD (Pb = 207.2)	
1 c.c. $\frac{N}{10}$ permanganate = 0.01036 gram lead	2.015 36
1 c.c. normal oxalic acid = 0.1036 gram lead	1.015 36
Metallic iron $\times 1.855$ = lead	0.268 41
Ferrous ammonium sulphate $\times 0.261$ = lead	1.421 92
MANGANESE (Mn = 54.93)	
MnO = 79.93, \therefore MnO ₂ = 86.93.	
Metallic iron $\times 0.4918$ = Mn	1.691 79
" $\times 0.6350$ = MnO	1.802 77
" $\times 0.7783$ = MnO ₂	1.891 15
Ferrous ammonium sulphate $\times 0.6907$ = MnO	2.957 61
" $\times 0.1112$ = MnO ₂	1.016 10
Cryst. oxalic acid $\times 0.6896$ = MnO ₂	1.838 60
1 c.c. $\frac{N}{10}$ solution = 0.003547 gram MnO	3.549 86
" " = 0.004347 gram MnO ₂	3.638 19
MERCURY (Hg = 200.6)	
Ferrous ammonium sulphate $\times 0.5115$ = Hg	1.708 86
" $\times 0.6924$ = HgCl ₂	1.840 33
1 c.c. $\frac{N}{10}$ solution = 0.02006 gram Hg	2.302 33
" " = 0.02086 gram Hg ₂ O	2.315 31
" " = 0.027152 gram HgCl ₂	2.433 80
NITROGEN AS NITRATES AND NITRITES	
N ₂ O ₅ = 108.02 N ₂ O ₃ = 76.02	
Normal acid $\times 0.0540$ = N ₂ O ₅	2.732 39
" $\times 0.1011$ = KNO ₃	1.004 75
Metallic iron $\times 0.3761$ = HNO ₃	1.575 39
" $\times 0.6035$ = KNO ₃	1.780 68
" $\times 0.3224$ = N ₂ O ₅	1.508 40
SILVER (Ag = 107.88)	
1 c.c. $\frac{N}{10}$ NaCl = 0.010788 gram Ag	2.032 94
" = 0.016989 " AgNO ₃	2.230 17

VOLUMETRIC FACTORS - *continued.*

		Logarithms.
SULPHURETTED HYDROGEN ($H_2S = 34.076$)		
1 c.c. $\frac{N}{10}$ arsenious solution --	0.002556 gram H_2S .	3.407 51
TIN ($Sn = 118.7$)		
Metallic iron	$\times 1.663 = \text{tin}$.	0.026 48
Ferrous ammonium sulphate	$\times 0.1514 \text{ tin}$.	1.179 98
Factor for $\frac{N}{10}$ iodine or permanganate solution		
0.005935		3.773 42
ZINC ($Zn = 65.37$)		
Metallic iron	$\times 0.5852 = Zn$.	1.767 33
"	$\times 0.7285 = ZnO$.	1.862 41
Ferrous ammonium sulphate	$\times 0.0836 = Zn$.	2.922 21
"	$\times 0.1041 = ZnO$.	1.017 45
1 c.c. $\frac{N}{10}$ solution	0.003268 gram Zn .	3.514 28

NITROMETER ANALYSIS.

1 c.c. NO at N.T.P. .	0.6257 mgm. N .	1.796 34
" " " 1.3402 "	NO .	0.127 17
" " " 1.6975 "	N_2O_3 .	0.229 81
" " " 2.4121 "	N_2O_5 .	0.382 40
" " " 2.8144 "	HNO_3 .	0.419 39
" " " 3.8009 "	KNO_2 .	0.579 88
" " " 4.5151 "	KNO_3 .	0.654 70
" " " 3.0819 "	$NaNO_2$.	0.488 82
" " " 3.7986 "	$NaNO_3$.	0.579 62
" " " 5.2294 "	$C_5H_5NO_2$.	0.718 45
" " " 3.3516 "	$C_2H_5NO_2$.	0.525 25
" at 15.6 C. = 3.170 "	" " .	0.500 89
and 760 mm.		

Temperature ° C.	For use in Calibrating Instruments.		For use with Standard Solutions.	
	Weight of 1 Litre of Water	Volume of 1 gram of Water.	Volume corresponding with 1 Litre at 15° C.	Volume of 1 c.c. reduced to 15° C.
5	grams. 998.6	c.c. 1.0014	c.c. 998.3	c.c. 1.0017
6	"	"	"	1.0016
7	"	"	"	1.0011
8	"	"	"	1.0013
9	"	"	"	1.0011
10	998.5	1.0015	998.0	1.0010
11	"	"	"	1.0008
12	998.1	1.0016	"	1.0006
13	"	1.0017	"	1.0004
14	"	1.0018	"	1.0002
15	"	1.0019	1000.0	1.0000
16	997.9	1.0021	"	0.9998
17	"	1.0022	"	0.9996
18	"	1.0023	"	0.9994
19	"	1.0025	"	0.9992
20	"	1.0027	1001.1	0.9989
21	"	1.0028	"	0.9987
22	997.0	1.0030	"	0.9984
23	996.8	1.0032	"	0.9982
24	"	1.0034	1002.0	0.9980
25	"	1.0037	"	0.9977

COEFFICIENTS OF ABSORPTION OF GASES IN WATER.

Gas.	1 volume of Water dissolves at 760 mm. Pressure.					Observer.
	0° C.	4° C.	10° C.	15° C.	20° C.	
Aceetylene,	1.73	1.53	1.31	1.15	1.03	Winkler
Air*,	0.02882	0.02606	0.02265	0.02046	0.01870	"
Ammonia,	1158.08	1048.23	898.67	770.29	696.17	Rose and Dittmar
Carbon monoxide, .	0.03537	0.03219	0.02816	0.02543	0.02319	Winkler
" dioxide,	1.713	1.473	1.194	1.019	0.878	Bohr and Bock
Chlorine,	3.0362		2.5852	2.3681	2.1665	Schönfeld
Hydrogen,	0.02148	0.02064	0.01955	0.01883	0.01819	Winkler
" sulphide,	4.3706	4.0442	3.5858	3.2326	2.9053	Schönfeld
Methane,	0.05473	0.05002	0.04366	0.03902	0.03498	Hinrichs
Nitric oxide, . . .	0.07381	0.06628	0.05700	0.051.7	0.04708	Winkler
Nitrous,	1.3052	1.1346	0.9196	0.7778	0.6700	Carius
Nitrogen,	0.02348	0.02130	0.01857	0.01682	0.01542	Winkler
Oxygen,	0.01890	0.04397	0.03802	0.03415	0.03102	"
Sulphur dioxide, .	79.789	69.828	56.647	47.276	39.374	Schönfeld

* Calculated from nitrogen and oxygen.

† At 16° C.

** Hydrogen chloride—506 vols. at 0° C., 474 at 10°, 458 at 15°, and 442 at 20°.

TABLE OF RECIPROCAL.

No.	Reciprocal.	No.	Reciprocal.	No.	Reciprocal.	No.	Reciprocal.
1	1	31	003226	61	01639	91	01099
2	5	32	003125	62	01613	92	01087
3	33333	33	003030	63	01587	93	01075
4	25	34	002941	64	01563	94	01064
5	2	35	02857	65	01539	95	01053
6	16667	36	02778	66	01515	96	01042
7	14286	37	02703	67	01493	97	01031
8	125	38	02632	68	01471	98	01020
9	11111	39	02564	69	01449	99	01010
10	1	40	025	70	01429	100	01
11	09091	41	02439	71	01409	101	00990
12	08333	42	02381	72	01389	102	00980
13	07692	43	02326	73	01370	103	00971
14	07143	44	02273	74	01351	104	00962
15	06667	45	02222	75	01333	105	00952
16	0625	46	02174	76	01316	106	00943
17	05882	47	02128	77	01299	107	00935
18	05556	48	02083	78	01282	108	00926
19	05263	49	02041	79	01266	109	00917
20	06	50	01	80	0125	110	00909
21	04762	51	01961	81	01235	111	00901
22	04545	52	01923	82	01220	112	00893
23	04318	53	01887	83	01205	113	00885
24	04167	54	01852	84	01191	114	00877
25	04	55	01818	85	01177	115	00870
26	03846	56	01786	86	01163	116	00862
27	03704	57	01754	87	01149	117	00855
28	03571	58	01724	88	01136	118	00847
29	03448	59	01695	89	01124	119	00840
30	03333	60	01667	90	01111	120	00833

Ex. 1. $\frac{100}{17} \times 01 = \frac{1}{17} = 0.05882.$

Ex. 2. $\frac{100}{43} \times 02 = \frac{1}{43} \times 2 = 02326 \times 2 = 0.04652.$

Ex. 3. $\frac{100}{82} \times 005 = \frac{1}{82} \times \frac{1}{2} = \frac{0.0122}{2} = 0.0061.$

VARIOUS USEFUL FACTORS.

To convert :—		multiplier	Logarithm
Grams per litre into grams	per cubic foot.	437.00	2.640 4754
" "	ounces (av.) "	0.99884	1.999 4973
" "	lb. "	0.06243	2.795 3773
" "	grams per fluid oz.	0.48847	1.641 8391
" "	grains per gallon	70	1.845 0980
Grains per gallon into cwt.	per million gallons	1.2755	0.105 6839
" "	grams per litre*	0.014286	2.154 9020
Percentage into grains per fluid oz.		4.375	0.640 9781
Percentage into grains per lb.		70	1.845 0980
Litres into cubic feet		0.035321	2.548 0345
Cubic inches into gallons		0.003604	3.556 7949
" feet " "		6.2279	0.794 3386
" yards " "		168.152	2.225 7026
15.68 grains per gallon = 1 ton per million gallons.			
* Or divide by 70.			

USEFUL DATA.

I. Areas and Volumes of Bodies.

			Logarithms.
Area of a Circle	$= \pi r^2$	r = radius	
		$\pi = 3.1415926$	0.497 1499
Volume of a sphere	$= \frac{4}{3} \pi r^3$	r = radius	
		$\pi = 3.1415926$	0.622 0886
Volume of a cylinder	$= \pi r^2 h$	r = radius of base	
		h = height	
Surface of Sphere	$= 4\pi r^2$	r = radius	
		$4\pi = 12.5664$	1.099 2099

II. Specific Gravity.

To convert :—

- (1) Degrees of Twaddell's hydrometer into sp. gr. (water = 1000)—multiply by 5 and add 1000
- (2) Sp. gr. (water = 1000) into degrees of Twaddell's hydrometer—subtract 1000 and divide by 5
- (3) The sp. gr. of gases referred to atmospheric air as unity = $\frac{34.52 \times \text{mol. wt.}}{1000} = \text{mol. wt.}$

1 kilogramme	= 2.20462262 pounds		0.859 3196
1 foot-pound	= 0.138255 kilogrammetres		1.140 6804

NOTES ON LOGARITHMS.

Definition.—The logarithm of a number N is the value of x which satisfies the equation $a^x = N$, where a is some given number.

Thus if a be 10 (which is the *base* of Briggs' or the ordinary logarithms), the logarithm of 100 is 2, that of 1000 is 3, and that of any number between 100 and 1000 will be greater than 2 and less than 3, so that it may be represented by 2 followed by places of decimals.

By means of a table of logarithms two numbers may be multiplied together by *adding* their logarithms and divided by *subtracting* their logarithms, the result in each case being the number corresponding to the logarithm thus obtained. Also, Involution, or raising of powers, is performed by multiplication of the logarithm of the number by the index of the power; and Evolution, or extraction of roots, by division of the logarithm of the number by the index of the root.

The integral part of a logarithm is called the *characteristic*, the decimal part the *mantissa*. The characteristic may be either positive or negative (e.g., 2, $\bar{2}$),* but the mantissa is *always positive*. The mantissa *only* are registered in the tables, the characteristics always being found by the following simple rules:—

(1) For numbers greater than unity, the characteristic is *one less* than the number of digits and is *positive*.

(2) For numbers less than unity, the characteristic is *one greater* than the number of ciphers which precede the first significant figure, and is *negative*.*

Ex. Log.	437.58	--2.6410575
Log.	43.758	1.6410575
Log.	4.3758	0.6410575
Log.	.43758	1.6410575
Log.	.043758	2.6410575

Negative characteristics are calculated according to the ordinary rules of algebraic addition and subtraction. A few examples will show the methods employed.

(1) Addition—

$$\begin{array}{r} \text{Add } 5.3468541 \\ 3.2685427 \\ \hline 2.6153968 \end{array}$$

+5 added to 3 gives +2.

$$\begin{array}{r} \text{Add } 6.8874651 \\ 2.9245630 \\ \hline 5.3120290 \end{array}$$

+6 is increased to +7 by the 1 carried over from the mantissa, and +7 added to 2 gives +5.

*The negative sign is placed over the characteristic to indicate that it alone is negative. If placed in front, like an ordinary negative sign, both characteristic and mantissa would become negative.

NOTES ON LOGARITHMS—*continued*.(1) Addition *continued*.

$$\begin{array}{r} \text{Add } 2.5632874 \\ \quad 3.2465281 \\ \hline 5.8098155 \end{array}$$

$$\begin{array}{r} \text{Add } 3.3010300 \\ \quad 2.9020029 \\ \hline 6.2030329 \end{array}$$

Here the 1 carried over from the mantissa is added to 3 giving 2, and 2 added to 2 gives 4.

(2) Subtraction --

Rule.—Change the sign of the characteristic in the lower line, and add as above.

$$\begin{array}{r} \text{From } 2.6847658 \\ \text{Subtract } 3.2468543 \\ \hline 5.4379115 \end{array}$$

3 becomes, on changing its sign, +3, and this added to +2 gives +5.

$$\begin{array}{r} \text{From } 2.3468537 \\ \text{Subtract } 5.7654626 \\ \hline 2.5813911 \end{array}$$

Here 1 is carried over from the mantissa, and has to be subtracted from 2, giving 3, then changing the 5 into +5, and adding this to 3, we have 8.

$$\begin{array}{r} \text{From } 5.6843252 \\ \text{Subtract } 3.7856310 \\ \hline 3.8986942 \end{array}$$

Here the 1 carried over subtracted from 5 gives 6; then changing 3 into +3 and adding it to 6, we have 9.

Proportional Parts.—When the logarithm of a number consisting of five figures or less is required, it can be found immediately in the tables; but if the numbers consist of more than five figures, a little calculation is required in order to find its correct logarithm. This calculation is greatly facilitated by the use of a *table of proportional parts*. It will be seen, on reference to the tables, that the differences between the logarithms of numbers differing by 1 in the fifth figure remain remarkably constant for a great many successive numbers, except at the beginning of the tables, where the changes are rather rapid. Thus, from 66500 to 67500 the difference between any two consecutive logarithms is uniformly 65: e.g., $\log. 66511 (=4.8228935)$ subtracted from $\log. 66512 (=4.8229000)$ gives 65. Suppose, then, we require the logarithm of a number consisting of six or seven figures, as for instance 66511.37, how do we proceed to find it?

NOTES ON LOGARITHMS—continued.

This is done as follows:—First write down the next lower logarithm.

$$\text{Log. } 66511 = 4.8228935,$$

then, since the difference of 1 in the fifth figure makes a difference of 65 in the logarithm, a difference of 37 will make a difference of $65 \times 37 = 24$.

$$\therefore \text{Log. } 66511.37 = 4.8228935 + 24 = 4.822959.$$

In the *table of proportional parts*, however, the amount to be added for every tenth of a unit is recorded, and by this table the above result may be easily found thus:

Log. 66511	=	4.8228935
Proportional part for .3	=	20
Proportional part for .67	=	46
		4.82289596

Conversely, the number to six, seven, or more figures corresponding to a given logarithm, is found by a method exactly the reverse of that given above.

Example.—Find the number whose log. is 2.9324547.

2.9324547	
2.9324535	log. 865.96
12	
10 =	.002
20 =	.0004

855.9624 the number required.

In the above example the difference between the given log. and the next lower in the tables being 12, the required number will evidently lie between 855.962 and 855.963, since the proportional part for 2 is 10 and that for 3 is 15. Subtracting that for 2, namely 10, we have 2 left. Annex a cipher to the 2, since the figure to be found will occupy the next decimal place, and the number 20 thus obtained is the proportional part for the figure 4.

COMPUTATION.

The following examples will show some of the methods that may be used with great advantage for reducing labour in working out the results of analytical and other chemical work :—

Ex. 1. Multiply 237.2 by 0.9889
 $9889 = 1 - 0.0111$
 Hence $237.2 \times 1 = 237.2$

 less the { 237.2
 sum of { 237.2
 { 0.2372

234.56708

Ex. 2. Multiply 578.643 by 2.987
 $2.987 = 3 - 0.013$
 $578.643 \times 3 = 1735.929$

 less the { 578.643
 sum of { 1.735929

1728.40641

Ex. 3. Multiply 182.76 by 5
 $= 182.76 \times \frac{10}{2} = 1827.6 \div 2 = 913.8$

Ex. 4. Multiply 32.8 by 15.
 $= 32.8 \times 10 = 328$
 $+ \text{half of } 32.8 \times 10 = 164$

492

Ex. 5. Multiply 0.07964 by 25
 $= 0.07964 \times \frac{100}{4} = \frac{7.964}{4} = 1.991$

Similarly to multiply by 25 use the fraction $\frac{100}{4}$

$$\text{Ex. 6. } 247.68 \times 125 = 247.68 \times \frac{1000}{8} = \frac{247680}{8} = 30960.$$

Similarly to multiply by 125 use 12^{th} ,
and to multiply by 125, simply divide by 8.

Ex. 7. In like manner, to *divide* by 25, •
 e.g. $\frac{5768}{25}$. This equal, $\frac{5768 \times 4}{100} = 5768 \div 4 \times 4$
230 72

APPROXIMATIONS

In many cases the results of chemical investigations may be regarded as accurate to the second or third decimal place only: hence it is simply misleading (not to say deceptive) to calculate such results to the fourth or fifth place of decimals. In these cases the following method of obtaining *approximate* results, correct to the first or second place of decimals, will be found invaluable.

Rule for multiplication.— Write the multiplier *backwards* under the multiplicand, and multiply in the usual way, each digit of the multiplier being multiplied into the figure immediately above it, those to the right being ignored, *except* that next to it, from which we get the amount to carry forward. •

The amount to be carried forward is taken as the nearest multiple of ten. Thus

any number from 1 to 4 counts zero

5 to 10 . 10

10 to 14	1
----------	---

15 to 20 " 2 and so on.

Omit all decimal points at first, the position of the decimal point in the answer being fixed afterwards,* as shown in the examples below.

Ex. 8. Multiply 47.26 by 1.43, giving four figures in the answer.

$$\begin{array}{r}
 4726 \\
 3421 \\
 \hline
 4726 \\
 945 \\
 189 \\
 14 \\
 \hline
 5874
 \end{array}
 \qquad
 \begin{array}{l}
 \text{In the second line } 2 \times 6 = 12 \\
 \qquad \qquad \qquad \cdot \text{ carry } 1 \\
 \qquad \qquad \qquad \bullet \\
 \text{,, third line } 4 \times 2 = 8 \\
 \qquad \qquad \qquad \bullet \text{ carry } 1 \\
 \qquad \qquad \bullet \\
 \text{, fourth line } 3 \times 7 = 21 \\
 \qquad \qquad \bullet \text{ carry } 2
 \end{array}$$

* "When I calculate I seldom trouble my head about the position of the decimal point in my answer until everything else is finished. There are many cleverly contrived rules about the position of the decimal point, but we forget them in practical work. Better never learn them."—Prof. John Perry, F.R.S.

To find where to put the decimal point, we notice that as 47 is nearly 50, the result will be rather less than $50 \times 12 = 600$. Hence the answer is obviously 587.1.

If greater accuracy had been required, we should have proceeded thus:—

$$\begin{array}{r}
 47260 \\
 3121 \\
 \hline
 47260 \\
 9152 \\
 1890 \\
 113 \\
 \hline
 58711 \quad \text{Result } 587.11.
 \end{array}$$

Ex. 9. Multiply 3.72 by .0005962.

Here we make 3.72 the multiplier as it shortens the work.

$$\begin{array}{r}
 5962 \\
 279 \\
 \hline
 17886 \\
 4173 \\
 119 \\
 \hline
 22178
 \end{array}$$

A: 3.72 is nearly 4, the answer will be rather less than $.0006 \times 4 = .0024$.

Hence the result is .0022178, or .00222 correct to the fifth decimal place.

Ex. 10. To find the number of feet in 726.422 metres, given that 1 metre = 3.2808 feet,

$$\begin{array}{r}
 726422 \\
 80823 \\
 \hline
 2179266 \\
 145284 \\
 58114 \\
 581 \\
 \hline
 2383245
 \end{array}$$

$726 \times 3 = 2178$, hence the answer is clearly 2383.245.

Rules for division.—Proceed as in the ordinary way, but instead of adding zeros to the dividend cut off digits from the divisor, carrying forward a figure from the digit rejected, just as in multiplication.

Ex. 11. Divide 271828 by 31416.

$$\begin{array}{r}
 3 \overline{) 271828} \quad (86525 \\
 \underline{251328} \\
 20500 \\
 \underline{18850} \\
 1650 \\
 \underline{1571} \\
 79 \\
 \underline{63} \\
 16 \\
 \underline{15} \\
 1
 \end{array}$$

Since $\frac{27}{31} = 0.8$, the answer is evidently 0.86525.

Ex. 12. How many cubic feet would be occupied by 1897.6 gallons of water? (6.228 gallons occupy 1 cubic foot.)

$$\begin{array}{r}
 6 \overline{) 1897.6} \quad (3047 \\
 \underline{18684} \\
 292 \\
 \underline{249} \\
 43 \\
 \underline{42} \\
 1
 \end{array}$$

Note that as 292 is not divisible by 6.228, we put 0 in the quotient and then divide by 6.2. The result is 304.7

Ex. 13. How many litres correspond to 6279864 cubic inches (1 litre = 61.035 cubic inches.)

$$\begin{array}{r}
 6 \overline{) 6279864} \quad (1028896 \\
 \underline{61035} \\
 176364 \\
 \underline{122070} \\
 54294 \\
 \underline{48828} \\
 5466 \\
 \underline{4882} \\
 584 \\
 \underline{549} \\
 35 \\
 \underline{36}
 \end{array}$$

Here, and in similar cases, proceed exactly as in ordinary division until all the figures in the dividend have been brought down, then begin to abbreviate. The result is seen at once to be 102889.6.

Examples requiring the use of Logarithms.

Ex. 14. To find a factor to multiply the number of c.c. of normal sulphuric acid required to saturate 20 c.c. of gas-liquor so as to give ounces of H_2SO_4 required per gallon

Let x be the number of c.c. of normal sulphuric acid used.

Then x c.c. contain $\cdot 019 x$ grams of H_2SO_4
 $\cdot 019 x$ grams for 20 c.c. will be

$$\frac{\cdot 019 \times 45 \cdot 45 \cdot 96}{20} x \text{ grams } \text{H}_2\text{SO}_4 \text{ per gallon}$$

or

$$\frac{\cdot 019 \times 45 \cdot 45 \cdot 96}{20 \times 2 \cdot 3155} x \text{ ounces } \text{H}_2\text{SO}_4 \text{ per gallon.}$$

To find the value of the fraction :—

log. $\cdot 019$	= 2.6901961	log. 20	= 1.3010300
.. $\sqrt{45 \cdot 45 \cdot 96}$	3.6576260	.. 2.3155	1.4525459
	2.3476221		2.7535759
	2.7535759		<u>2.7535759</u>
	1.5912462		0.30287.

The log thus obtained may now be abbreviated to 1.59125.
 Suppose that 32.8 c.c. of normal H_2SO_4 were required, then

$$\begin{array}{r} \log. 32.8 = 1.51587 \\ 1.59125 \\ \hline 1.11912 = 12.89 \text{ ounces } \text{H}_2\text{SO}_4 \text{ per gallon.} \end{array}$$

Logarithms should not *always* be used in similar cases, since by cancelling out common factors in numerator and denominator some fractions reduce to very simple forms. Thus in a certain calculation the following factor was required :—

$$\text{Ex. 15. } \frac{480 \times 20 \times 30}{144 \times 7000} \text{ which readily reduces to } \frac{2}{7}.$$

INDIRECT ANALYSIS.

The methods used are best shown by examples.

Ex. 1. A mixture of chloride of potassium and sodium weighs 0.9800 gram, and it contains 0.5633 gram of chlorine : to find the amount of each chloride present.

Let x = weight of NaCl present.
 y = weight of KCl
 1 part by weight of NaCl contains 0.6066 Cl
 1 " " KCl " 0.4756 Cl
 (See Table of Percent. Compositions.)

$$\begin{aligned} \therefore \quad & x + y = 0.9800 \quad (i) \\ & 0.6066x + 0.4756y = 0.5633 \quad (ii) \\ (ii) \quad & 0.6066x + 0.4756y = 0.5633 \\ (i) \times 0.4756 \quad & 0.4756x + 0.4756y = 0.4661 \end{aligned}$$

$$\begin{aligned} & 1310x = 0.0972 \\ & x = \frac{0.0972}{131} = 0.7420 \text{ gram NaCl.} \end{aligned}$$

From (i) $y = 0.9800 - 0.7420 = 0.2380$ gram KCl.

Hence the mixture contains

$$\begin{aligned} & 74.2 \times 100 = 75.71\% \text{ NaCl} \\ & 23.8 \times 100 = 24.29\% \text{ KCl.} \end{aligned}$$

The general rule in this case is found as follows :—

Let w = weight of mixed chlorides of sodium and potassium
 z = weight of chlorine
 and x = weight of NaCl present.

$$\begin{aligned} \text{Then } 0.6066x + 0.4756(w - x) &= z \\ 131x + 4756(w - x) &= 131z \\ 131x &= \frac{z}{0.4756} - 0.4756w \\ \text{or } 2754.4x &= 2.1026z - 0.4756w \\ x &= 3.6305(2.1026z - w). \end{aligned}$$

Hence the rule :—

Multiply the weight of chlorine present by 2.1026, and subtract from the product the weight of the mixed chlorides. The remainder multiplied by 3.6305 will give the weight of sodium chloride present in the mixture.

$$\log 2.1026 = 0.32276 \quad \log 3.6305 = 0.55997$$

THE PRECIPITATING POWERS OF A FEW COMMON REAGENTS

1. Ammonium oxalate. $(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$.

10 grams per litre.

For 1 gram taken

10 c.c. will precipitate	15.78 per cent.	CaO .
"	28.17	CaCO_3 .
"	38.31	CaSO_4 .
"	29.11	$\text{Ca}_3\text{P}_2\text{O}_8$.

2. Barium chloride. $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$.

100 grams per litre

For 1 gram taken

10 c.c. will precipitate	13.11 per cent.	S .
"	22.79	SO_2 .
"	10.16	H_2SO_4 .
"	55.64	CaSO_4 .

3. Hydrogen disodium phosphate. $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$.

100 grams per litre.

For 1 gram taken

10 c.c. will precipitate	11.17 per cent.	MgO .
"	23.46	MgCO_3 .
"	33.51	MgSO_4 .

4. Magnesia Mixture.

Dissolve 10 grams of "Magnesia" in HCl , and add a solution of 200 grams of NH_4Cl in the least possible quantity of water. Add 0.960 ammonia till a slight precipitate forms, and filter. Make up the clear filtrate to 1500 c.c. with distilled water, and add 750 c.c. 0.960 ammonia. Shake well, allow to stand, and filter for use. This solution remains clear on diluting with fairly strong ammonia, and for 1 gram of a substance taken

10 c.c. will precipitate 60 per cent. $\text{Ca}_3\text{P}_2\text{O}_8$.

Thus, if 1 gram of a Belgian Phosphate were taken for analysis, 10 c.c. would doubtless be sufficient to precipitate the P_2O_5 present, but 15 c.c. would be the proper amount to add, the excess being tested for in the filtrate in the usual way.

5. Ammonium molybdate solution.

Dissolve 50 grams of ammonium molybdate in 200 c.c. of 0.960 ammonia at a gentle heat, and pour into a mixture of 400 c.c. strong nitric acid, and 400 c.c. water contained in a beaker standing in water, adding the molybdate solution slowly with constant stirring. Allow the solution to stand, and filter for use.

100 c.c. will precipitate 0.10 gram P_2O_5 .

* The strength of each batch should be determined and marked on the stock bottle. It usually comes out about 65 per cent.

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS.
 (= crystallized. A = anhydrous.

Name.	Formula.	Molecular Weight.	Percentage Composition.
ALUMINIUM $Al = 27.1$			
Aluminium chloride.	Al_2Cl_6	266.66	A 20.93; Cl 79.07
hydrate.	$Al_2(OH)_6$	156.44	Al 65.43; H ₂ O 34.569
oxide.	Al_2O_3	102.2	A 52.93; O 46.97
.. sulphate,	$Al_2(SO_4)_3 \cdot 18H_2O$	1000.66	Al ₂ O ₃ 13.93; SO ₃ 36.03; H ₂ O 49.93
Alum (ammonia).	$Al(NH_4)SO_4 \cdot 24H_2O$	1000.66	Al ₂ O ₃ 11.37; NH ₃ 7.75; SO ₃ 35.31; H ₂ O 49.93
.. potash.	$AlK(SO_4)_2 \cdot 24H_2O$	1000.66	Al ₂ O ₃ 10.77; K ₂ O 9.93; SO ₃ 33.75; H ₂ O 45.25
AMMONIUM $NH_4 = 18.042$			
Ammonia.	NH_3	17.03	N 82.25; H 17.75
Ammonium carbonate.	$(NH_4)_2CO_3$	97.962	NH ₃ 7.39; H ₂ O 2.61
.. chloride	NH_4Cl	53.462	NH ₃ 21.27; HNO ₃ 78.73
.. nitrate.	NH_4NO_3	80.052	NH ₃ 27.46; H ₂ O 72.54
.. oxalate.	$(NH_4)_2C_2O_4 \cdot 2H_2O$	146.084	NH ₃ 25.75; H ₂ O 74.25
.. phosphate.	$(NH_4)_3PO_4$	132.132	NH ₃ 25.75; H ₂ O 74.25
.. sulphate.	$(NH_4)_2SO_4$	132.144	NH ₃ 25.75; H ₂ O 74.25
.. thiocyanate.	$(NH_4)_2SCN$	76.132	NH ₃ 25.38; H 1.32; CN 84.17

ANTIMONY. $S = 10.2$			
Antimony trichloride,	SbCl_3	226.58	$\text{Sb}_2\text{O}_3 = 140.95$
Antimonyous oxide,	Sb_2O_3	238.4	$\text{Sb}_2\text{O}_3 = 140.95$
Antimony tetroxide,	Sb_2O_4	304.4	$\text{Sb}_2\text{O}_4 = 140.95$
Antimony trisulphide,	Sb_2S_3	336.58	$\text{Sb}_2\text{S}_3 = 140.95$
ARSENIC ($A = 74.96$)			
Arsenic trichloride,	AsCl_3	151.34	$\text{As}_2\text{O}_3 = 197.44$
Arsenious chloride,	As_2O_3	197.44	$\text{As}_2\text{O}_3 = 197.44$
Arsenic trisulphide,	As_2S_3	246.15	$\text{As}_2\text{S}_3 = 197.44$
" pentoxide,	As_2O_5	229.92	$\text{As}_2\text{O}_5 = 197.44$
BARIUM ($Ba = 137.37$)			
Barium carbonate,	BaCO_3	197.37	$\text{BaO} = 153.34$
" chlorite,	$\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$	244.32	$\text{BaO} = 153.34$
" nitrate,	$\text{Ba(NO}_3)_2$	261.30	$\text{BaO} = 153.34$
" oxide,	BaO	153.34	$\text{BaO} = 153.34$
" hydroxide,	$\text{Ba(OH)}_2 \cdot 8\text{H}_2\text{O}$	315.514	$\text{BaO} = 153.34$
" sulphate,	BaSO_4	233.43	$\text{BaO} = 153.34$
BISMUTH ($Bi = 208$)			
Bismuth chloride,	BiCl_3	314.98	$\text{Bi}_2\text{O}_3 = 465.76$
" oxide,	Bi_2O_3	465.76	$\text{Bi}_2\text{O}_3 = 465.76$
" nitrate,	$\text{Bi(NO}_3)_3 \cdot 5\text{H}_2\text{O}$	591.05	$\text{Bi}_2\text{O}_3 = 465.76$
BORON ($B = 10.8$)			
Boric anhydride,	B_2O_3	69.8	$\text{B}_2\text{O}_3 = 10.8$
" acid,	H_3BO_3	61.824	$\text{B}_2\text{O}_3 = 10.8$

FORMULAE, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—continued.

C = crystallized A = anhydrous.

Name.	Formula	Molecular Weight	Percentage Composition.
CADMIUM $Cd = 112.4$			
Cadmium chloride.	$CdCl_2 \cdot H_2O$	201.33 (A) 201.33	$CdCl_2$ 91.05; H_2O 8.95
" oxide.	CdO	128.4	Cd 87.54; O 12.46
" sulphide.	CdS	144.46	Cd 77.80; S 22.20
CALCIUM $Ca = 40.07$			
Calcium chloride.	$CaCl_2 \cdot 4H_2O$	219.02 (A) 146.90	$CaCl_2$ 36.10; H_2O 63.90
" carbonate.	$CaCO_3$	100.09	CaO 56.02; CO_2 43.98
" fluorosulphate.	CaF_2	78.07	Ca 51.35; F 48.65
" hydroxide.	$CaOH_2$	74.08	Ca 75.05; H 6.24; O 18.71
" nitrate.	$Ca(NO_3)_2 \cdot 4H_2O$	236.15 (A) 146.00	Ca 30.31; N 9.65; O 55.83
" oxide.	CaO	56.07	Ca 71.05; O 28.95
" sulphate.	$CaSO_4 \cdot 2H_2O$	172.12 (A) 136.10	CaO 28.57; SO_3 68.51; H_2O 20.92
Monocalcium phosphate.	CaH_2PO_4	132.07	Ca 40.51; P 19.80; O 39.69
Tricalcium phosphate.	$Ca_3(PO_4)_2$	261.82	CaO 28.51; P_2O_5 40.97; H_2O 15.39
Calcium sulphide.	CaS	80.10	Ca 54.21; S 45.79
" "	"	75.1	Ca 55.83; S 44.17
CARBON $C = 12$			
Carbon monoxide.	CO	28	C 42.86; O 57.14
" dioxide.	CO_2	44	C 27.27; O 72.73

CHROMIUM $\text{Cr} = 52$		
Chromic chloride	Cr_2Cl_6	
" oxide	Cr_2O_3	Cr 32.18 ; O 67.81
" sulphate	$\text{Cr}_2(\text{SO}_4)_3$	Cr 28.42 ; O 31.57 ; S 39.99
COBALT $\text{Co} = 58.93$		
Cobaltous chloride	CoCl_2	Co 45.40 ; Cl 54.60
" nitrate	$\text{Co}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$	Co 27.68 ; N 15.57 ; H ₂ O 56.75
Cobalt monoxide	Co_2O_3	Co 78.68 ; O 21.31
COPPER $\text{Cu} = 63.55$		
Cuprous chloride	Cu_2Cl_2	Cu 47.27 ; Cl 52.72
" oxide	Cu_2O	Cu 88.80 ; O 11.20
" sulphate	Cu_2SO_4	Cu 79.88 ; S 20.11
Cupric chloride	CuCl_2	Cu 47.27 ; Cl 52.72
" oxide	CuO	Cu 79.88 ; O 20.11
" sulphate	CuSO_4	Cu 63.55 ; S 20.11
" sulphate	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	Cu 38.47 ; S 20.11 ; H ₂ O 41.42
HYDROGEN $\text{H} = 1.008$		
Hydrogen chloride	HCl	H 25.13 ; Cl 74.86
" bromide	HBr	H 23.65 ; Br 76.35
" iodide	HI	H 12.74 ; I 87.25
" nitrate	HNO_3	N 22.05 ; O 77.95 ; H 1.00
" sulphate	H_2SO_4	S 32.05 ; O 67.95 ; H 1.00

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—continued.
 C = crystallized. A = anhydrous.

Name.	Formula.	Molecular Weight.	Percentage Composition.
IRON (Fe = 55.84)			
Ferrous chloride,	FeCl_2	126.76	Fe 41.06; Cl 58.95
" carbonate,	FeCO_3	115.84	Fe 46.02; C 10.27; O 43.71
" oxide,	FeO	71.84	Fe 77.75; O 22.25
" sulphate	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$	(C) 278.012 (A) 151.991	Fe 25.54; S 12.48; O 48.96; H_2O 13.98 (Fe = 55.84)
" ammonium sulphate,	$\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	(C) 392.143 (A) 284.941	37.02; Fe 16.17; N 8.51; S 12.48; O 37.82
" sulphide,	FeS	87.90	Fe 57.72; S 42.28
Ferric chloride,	Fe_2Cl_6	321.44	Fe 34.72; Cl 65.28
" oxide,	Fe_2O_3	159.68	Fe 69.91; O 30.09
Triferic trioxide,	Fe_3O_4	231.52	Fe 72.36; O 27.64
Iron chloride,	Fe_2Cl_3	119.96	Fe 66.51; S 33.49
Ferric sulphate	$\text{Fe}_2(\text{SO}_4)_3$	392.56	Fe 30.33; S 12.48; O 57.19
LEAD (Pb = 207.2)			
Lead acetate,	$\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3\text{H}_2\text{O}$	(C) 370.996 (A) 299.248	Pb 55.75; C 25.75; H 14.20
" carbonate,	PbCO_3	257.2	Pb 58.75; C 10.47
" chloride,	PbCl_2	277.12	Pb 74.49; Cl 25.51
" chromate,	PbCrO_4	323.2	Pb 69.55; Cr 10.90; O 19.55
" nitrate,	$\text{Pb}(\text{NO}_3)_2$	331.22	Pb 67.38; N 10.32; O 22.62
Plumbic oxide,	PbO	223.2	Pb 92.83; O 7.17
" dioxide,	PbO_2	239.2	Pb 86.62; O 13.38
Triplumbic tetroxide,	Pb_3O_4	685.6	Pb 99.96; O 0.04
Lead sulphide,	PbS	239.27	Pb 86.59; S 13.41
" sulphate,	PbSO_4	303.27	Pb 73.56; S 12.48; O 13.96

• MAGNESIUM, (Mg=24.32)			
Magnesium chloride . .	$MgCl_2 \cdot 6H_2O$	(C) 29.8336 (A) 95.245 f	(A) Mg 25.54 ; Cl 74.46
" carbonate, . .	$MgCO_3$	84.32	MgO 47.52 ; CO_2 52.48
" oxide, . .	MgO	40.31	Mg 60.32 ; O 39.68
" nitrate, . .	$Mg(NO_3)_2 \cdot 6H_2O$	(C) 25.6436 (A) 118.346 f	(A) MgO 27.18 ; N_2O_5 72.82
" sulphate, . .	$MgSO_4 \cdot 7H_2O$	(C) 24.4492 (A) 120.384 f	MgO 14.38 ; SO_3 32.48 ; H_2O 53.16
Magnesium ammonium phosphate, . .	$Mg_2(NH_4)_2(PO_4)_3 \cdot 12H_2O$	(C) 400.966 (A) 271.89 f	•
" pyrophosphate, . .	$Mg_2P_2O_7$	222.72	MgO 30.21 ; P_2O_5 65.79
• MANGANESE, (Mn=54.93)			
Manganese carbonate, . .	$MnCO_3$	114.93	MnO 61.72 ; CO_2 38.28
" chloride, . .	$MnCl_2 \cdot 4H_2O$	(C) 167.244 (A) 135.850 f	(A) Mn 41.37 ; Cl 58.63
" oxide, . .	MnO	79.92	Mn 67.42 ; O 32.58
" silicate, . .	$MnSiO_3 \cdot H_2O$	(C) 241.97 (A) 157.63 f	(A) MnO 30.27 ; SiO_2 58.98
" sulphide, . .	MnS	87.90	Mn 63.1 ; S 36.9
Manganese dioxide, . .	MnO_2	56.93	Mn 63.1 ; O 36.9
" sesquioxide, . .	Mn_2O_3	157.86	Mn 69.7 ; O 30.3
Trimanganese tetroxide, . .	Mn_3O_4	238.79	Mn 72.93 ; O 27.07
• MERCURY, (Hg=200.6)			
Mercurous chloride, . .	Hg_2Cl_2	472.12	Hg 84.98 ; Cl 15.02
" nitrate, . .	$Hg_2(NO_3)_2 \cdot 2H_2O$	(C) 561.252 (A) 225.226 f	(A) HgO 74.33 ; N_2O_5 19.25 ; H_2O 6.42
" oxide, . .	HgO	177.9	Hg 96.26 ; O 3.74
Mercuric chloride, . .	$HgCl_2$	271.52	Hg 73.58 ; Cl 26.42

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—continued.

Name.	Formula.	Molecular Weight.	Percentage Composition.	
			C=crystallized.	A=anhydrous.
MERCURY ($Hg = 200.6$)— <i>contd.</i>				
Mercuric nitrate,	$2Hg(NO_3)_2 \cdot H_2O$	$\left. \begin{array}{l} (C) 587.254 \\ (A) 449.240 \end{array} \right\}$	$HgO \ 64.92; N_2O_5 \ 32.38; H_2O \ 2.70$	
.. oxide,	HgO	216.6	$Hg \ 92.61; O \ 7.39$	
.. sulphide,	HgS	282.66	$Hg \ 86.59; S \ 13.75$	
.. sulphate,	$HgSO_4$	296.66	$HgO \ 73.64; SO_3 \ 26.36$	
NICKEL ($Ni = 58.69$)				
Nickel chloride,	$NiCl_2 \cdot 6H_2O$	139.6	$Ni \ 16.28; Cl \ 54.72$	
.. monoxide,	NiO	74.68	$Ni \ 78.68; O \ 21.32$	
.. sulphate,	$NiSO_4 \cdot 7H_2O$	$\left. \begin{array}{l} (C) 280.352 \\ (A) 180.710 \end{array} \right\}$	$NiO \ 26.59; SO_3 \ 28.51; 7H_2O \ 44.90$	
.. mon-sulphide,	NiS	90.74	$Ni \ 64.66; S \ 35.34$	
.. nitrate,	$Ni(NO_3)_2 \cdot 6H_2O$	$\left. \begin{array}{l} (C) 290.700 \\ (A) 182.700 \end{array} \right\}$	$Ni(NO_3)_2 \ 62.58; H_2O \ 37.47$	
PHOSPHORUS ($P = 31.04$)				
Hypophosphorous acid,	H_3PO_2	66.04		
Phosphorous	H_3PO_3	82.04		
Phosphoric	H_3PO_4	98.04	$P_2O_5 \ 79.14; H_2O \ 27.56$	
Metaphosphoric	HPO_3	59.04	$P_2O_5 \ 88.77; H_2O \ 27.25$	
Pyrophosphoric	$H_4P_2O_7$	178.12	$P_2O_5 \ 79.77; H_2O \ 29.23$	
Phosphorus pentoxide,	P_2O_5	142.08	$P_2O_5 \ 100; O \ 56.33$	
PLATINUM ($Pt = 195.2$)				
Platinum tetrachloride,	$PtCl_4$	337.04	$Pt \ 57.92; Cl \ 42.08$	
Ammonium platino-chloride,	NH_4PtCl_6	444.04	$Pt \ 43.96; NH_3 \ 7.67; N \ 6.31$	
Potassium	K_2PtCl_6	486.16	$Pt \ 40.15; Cl \ 43.77; K \ 16.08$	$KCl \ 56.57 = K_2O \ 19.5$

PERCENTAGE COMPOSITIONS.

Potassium (K=39.1)			
Potassium acetate,	$\text{KC}_2\text{H}_3\text{O}_2$		95.124
" bromide,	KBr		51.912
" carbonate,	K_2CO_3		1.882
" bicarbonate,	KHCO_3		100.198
" chloride,	KClO_3		122.58
" chlorite,	KCl		74.556
" cyanide,	KCN		65.11
" chromate,	K_2CrO_4		194.2
" dichromate,	$\text{K}_2\text{Cr}_2\text{O}_7$		294.2
" ferrocyanide,	$\text{K}_4\text{Fe}(\text{CN})_6 \cdot 3\text{H}_2\text{O}$	{	$\left\{ \begin{array}{l} \text{A } 422.18 \\ \text{A } 345.21 \end{array} \right.$
" ferrivanadate,	$\text{K}_4\text{Fe}(\text{CN})_6$		
" hydroxide,	KOH		56.108
" iodide,	KI		166.92
" nitrate,	KNO_3		101.11
" nitrite,	KNO_2		87.11
" oxide,	K_2O		94.2
" persulfate,	$\text{K}_2\text{S}_2\text{O}_8$		288.43
" sulfate,	K_2SO_4		174.26
" bisulfate,	KHSO_4		136.168
" sulfide,	K_2S		110.28
" sulphite,	$\text{K}_2\text{S}_3\text{O}_6 \cdot 2\text{H}_2\text{O}$	{	$\left\{ \begin{array}{l} \text{A } 190.42 \\ \text{A } 152.20 \end{array} \right.$
" thiocyanate,	KSCN		
Silica,	SiO_2		53.13
Silver,	Ag		107.881
" bromide,	AgBr		187.76
" chloride,	AgCl		143.34

K 32.55; Br 67.45
K ₂ O 68.49; CO ₂ 31.51
K ₂ O 47.05; O ₂ 42.95; H ₂ O 9.00
K 81.99; Cl 18.01; O 0.01
K 52.44; Cl 47.56
K 60.05; CN 39.95
K ₂ O 48.31; Cr ₂ O ₃ 51.69
K ₂ O 29.02; Fe ₂ O ₃ 70.98
K 73.13; Fe 1.92; N 30.95
H ₂ O 1.95
K 55.03; Fe 16.95; N 17.11
K ₂ O 83.92; H ₂ O 16.08
K 3.55; N 1.76
K ₂ O 36.78; N 63.22
K 65.34; N 34.66
K ₂ SO ₄ 100.00
K ₂ O 68.80; Al ₂ O ₃ 31.20
K ₂ O 51.57; SO ₃ 48.43
K ₂ O 52.50; SO ₃ 47.50; H ₂ O 0.01
K 70.00; N 30.00
K ₂ O 48.18; SO ₃ 51.82; H ₂ O 0.01
K 10.23; N 89.77

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—continued.

C = cry-stallized. A = aq-uiv-its.			
Name.	Formula.	Molecular Weight.	Percentage Composition.
SILVER, $Ag = 107.88$ —contd.			
Silver nitrate.	$AgNO_3$	169.89	Ag 65.50; NO ₂ 34.50
" sulphide.	Ag_2S	247.82	Ag 87.95; S 12.05
" sulphate.	Ag_2SO_4	371.82	Ag 74.82; SO ₃ 25.18
SODIUM, $Na = 23$			
Sodium acetate.	$NaC_2H_3O_2 \cdot 3H_2O$	136.072	Na 37.76; Ac 62.24
" bicarbonate.	$NaHCO_3$	84.066	Na 27.09; CO ₂ 72.91
" borate.	$Na_2B_4O_7 \cdot 10H_2O$	380.37	Na 10.21; B ₂ O ₃ 39.57
" carbonate.	Na_2CO_3	106.02	Na 47.46; CO ₂ 52.54
" bicarbonate.	$NaHCO_3$	84.066	Na 27.09; CO ₂ 72.91
" chloride.	$NaCl$	58.46	Na 39.34; Cl 60.66
" chromate.	Na_2CrO_4	162	Na 35.27; Cr 64.73
" hydroxide.	$NaOH$	40.008	Na 57.48; H 1.12; O 41.40
" nitrate.	$NaNO_3$	85.01	Na 29.52; N 16.48; O 54.00
" nitrite.	$NaNO_2$	69.01	Na 27.09; N 16.48; O 56.43
" oxide.	Na_2O	62.01	Na 75.19; O 24.81
" phosphate.	$Na_2HPO_4 \cdot 12H_2O$	358.14	Na 17.31; P ₂ O ₅ 19.83; H ₂ O 62.86
" sulphate.	$Na_2SO_4 \cdot 10H_2O$	320.06	Na 19.24; SO ₃ 24.85; H ₂ O 55.91
" bicarbonate.	$NaHCO_3$	84.066	Na 27.09; CO ₂ 72.91

SODIUM (Na=23)—continued.			
Sodium sulphide, . . .	Na_2S		$\text{Na}_2\text{S } 58.92; \text{S } 41.08$
.. sulphite, . . .	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 7\text{H}_2\text{O}$		$\text{Na}_2\text{O } 24.59; \text{SO}_2 } 25.41; \text{H}_2\text{O } 50.00$ (C) 25.712
.. thiosulphate, . . .	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$		$\text{Na}_2\text{O } 24.98; \text{S } 12.92; \text{SO}_2 } 25.81$ (C) 24.820
STRONTIUM (Sr=87.63)			$\text{H}_2\text{O } 59.29$ (A) 15.812
Strontium carbonate, . .	SrCO_3		147.63
.. chloride, . . .	$\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$		(C) 66.646
.. nitrate, . . .	$\text{Sr(NO}_3)_2$		(A) 15.850
.. oxide, . . .	SrO		211.65
STRONTIUM (S=32.06)			103.63
Sulphur dioxide, . . .	SO_2		31.00
.. trioxide, . . .	SO_3		50.00
Sulphuretted hydrogen, .	H_2S		34.076
TIN (Sn=118.7)			
Stannous chloride, . . .	$\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$		$\text{Sn } 52.00; \text{Cl } 31.13; \text{H}_2\text{O } 15.87$
.. oxide, . . .	SnO		$\text{Sn } 72.12; \text{O } 11.88$
Stannic oxide, . . .	SnO_2		$\text{Sn } 75.77; \text{O } 14.23$
ZINC (Zn=65.37)			
Zinc carbonate, . . .	ZnCO_3		125.37
.. chloride, . . .	ZnCl_2		136.29
.. oxide, . . .	ZnO		81.37
.. sulphate, . . .	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$		(C) 25.712
.. sulphide, . . .	ZnS		(A) 161.43
WATER,	H_2O		97.43
			18.016
			$\text{H } 11.19; \text{O } 88.81$

NOTES ON INDICATORS.

I.—Litmus solution. A solution of a carbonate whilst being titrated should be boiled to expel the free CO_2 , otherwise it is easy to overstep the exact point of neutrality. The titration cannot be done by gas-light.

According to B. Reintzer (see Abstract, *Analyst*, 1891, p. 255) litmus is the most serviceable indicator, exceeding methyl orange in sharpness of change of colour, and sensitiveness, while it possesses an advantage over phenol-phthalein in being capable of being used in the presence of ammonium salts. Good litmus should be used; the solution must be boiled for seven or eight minutes and then neutralized with HCl , so that the wine-red colour remains even on further boiling; the solution is then cooled, and an equal volume of strong alcohol added. The stock solution should be kept in a bottle with a delivery pipette inserted through the cork. The final change of colour is sharpest when the liquid to be titrated is boiled for seven or eight minutes and then well cooled. Lunge has found (see Abstract *Analyst*, 1895, p. 65) that litmus is only twice as sensitive as methyl orange, against eight times as claimed by Reintzer. With normal acid practically identical results are obtained, but methyl orange is preferable on account of its speed and the precautions to be observed in the use of litmus. It is only with decinormal acid that litmus is undoubtedly superior, and Reintzer's method of titration must be observed. Whatever indicator be used the fluid must be cold when titrated.

It is dangerous to titrate carbonates, using litmus or phenol-phthalein as indicator, the boiling should be carried out in vessels of porcelain, platinum or silver; an even Jean glass is attacked by hot soda solutions (Lunge).

II.—Methyl orange (the sodium salt of dimethyl amido-azo-benzene-sulphonic acid).

Solution. 0.5 gram in a litre of distilled water.

Unlike litmus, this indicator is unaffected by CO_2 , H_2S , boric, arsenious, hydrocyanic, oleic, stearic, palmitic, and carboxylic acids, &c. It must not be used for organic acids; nor in the presence of nitrous acid or nitrites, which decompose it. It acts admirably with mineral acids, and with ammonia and its salts. Ordinary temperatures should be observed.

Colour reaction.—Faint yellow if alkaline, pink if acid.

The use of methyl orange is recommended by Lunge (1903) for all cases, except that of weak acids, for which phenol-phthalein should be employed. The strength of solutions titrated should not be less than one-fifth normal.

As methyl orange is often adulterated with dextrin and other substances, every new lot purchased should be carefully tested, especially as to whether it gives a sharp change of colour with a mineral acid.

III.—Phenol-phthalein ($\text{C}_{20}\text{H}_{14}\text{O}_4$).

Solution. Dissolve 4 grams in 600 c.c. of strong alcohol, then add gradually with constant stirring 400 c.c. of distilled water.

It is useless for the titration of free ammonia or its compounds, or for the fixed alkalis, when salts of ammonia are present. Unlike methyl orange, it is especially useful in titrating all varieties of organic acids—viz., oxalic, acetic, citric, tartaric, &c. It may be used either in alcoholic solutions or in mixtures of alcohol and ether. It gives no colour with bicarbonates.

Colour reaction. Colourless in neutral or acid liquids, but rendered purple-red by faint excess of caustic alkali.

IV. Cochineal solution.

Solution.—Digest one part of powdered cochineal with 10 parts of 25 per cent. alcohol.

It is not very much modified in colour by CO_2 and may be used by daylight. Most useful in titrating solutions of the alkaline earths, such as lime and baryta-water. Inapplicable in the presence of even traces of Fe or Al compounds or acetates.

Colour reaction. Turned violet by alkalis; the original yellowish red color being restored by mineral acids.

V. Phenacetolin.

Solution. Two grains in a litre of alcohol.

This indicator may be used to estimate the amount of KOH or NaOH in the presence of K_2CO_3 or Na_2CO_3 , or of CaO in the presence of CaCO_3 .

Colour reaction —

With NH_3 and normal alkali carbonates dark pink.

“	bicarbonates	— intense pink.
“	mineral acids	— golden yellow.

VI. Rosolic Acid ($C_{10}H_8O_4$).

Solution. Two grams in a litre of 50 per cent. alcohol.

This indicator is excellent for all the mineral, but useless for the organic acids, except oxalic. It may be relied on for the neutralization of SO_3 with ammonia to normal sulphite.

Colour reaction. The pale yellow colour is unaffected by acids, but changed to violet-red by alkalis.

VII.—**Iacmoid.**

Solution. Three grams may be dissolved in a litre of dilute alcohol, but Forster recommends the addition of 5 grams of naphthol green to the above. The effect is to produce a more decided blue colour with alkalis than is given by haemoid alone.

Colour reaction.— Blue in alkaline, red in acid, solution.

VIII.—Congo Red.

Solution.—One gram in 100 c.c. of 70 per cent. alcohol. Specially useful in determining free mineral acids in the presence of most organic acids.

Colour reaction. Red in alkaline solution, turning blue with excess of acid.

Turmeric Paper—Digest one part of powdered turmeric with six parts of weak alcohol, filter, and steep some filter paper in the filtrate. The paper, when dry, must exhibit a fine yellow tint, or be readily wetted by aqueous fluids. Cut into strips and keep in a well-stoppered bottle covered with black paper.

I. IMPERIAL SYSTEM.

Avoirdupois Weight.

16 drams (dr.)	= 1 ounce (oz.)	= 437.5 grains*	log. 437.5 = 2.640 9781
16 ounces	= 1 pound (lb.)	= 7000 „	log. 7000 = 3.845 0980
14 pounds	= 1 stone		
28 „	= 1 quarter		
100 „	= 1 cental		
4 quarters	= 1 hundredweight (cwt.)	= 112 lb.	log. 112 = 2.049 2180
20 cwt.	= 1 ton	= 2240 lb.	log. 2240 = 3.350 2480

Note. 1 dram = 27.34375 grains (log. 1.436 8581).

24 grains (and its multiples 48, 72, 120, and 144 grains) are legal weights and are commonly called *poenceweights*.

Troy Weight.

1 troy ounce (oz. tr.) = 480 grains† log. 2.681 2112

Weights less than a troy ounce are expressed as decimals of an ounce, not in grains. For greater weights, ounces only are used, there being no troy pound.

Apothecaries' Weight.

20 grains* (gr.)	= 1 scruple (℥)
3 scruples or 60 grains	= 1 drachm (ʒ)
8 drachms or 480 grains	= 1 ounce (℥)

Apothecaries' Measures.

60 minims (non.)	= 1 fluid drachm (fl. dr. or ℥ ʒ)
8 fluid drachms	= 1 fluid ounce (fl. oz. or ℥ ʒ)
20 fluid ounces	= 1 pint (O)†
8 pints	= 1 gallon (G)‡

Relations of Apothecaries' Measures to Weights.

(All liquids to be measured at 62° Fah.)

		Logarithms
1 minim is the measure of	0.9115 grain weight of water	1.959 7368
1 fluid drachm	54.687 grains	1.737 8881
1 fluid ounce	437.5 „	2.640 9781
1 pint	8750 „	3.942 0681
1 gallon	70000 „	4.845 0980
1 pint = 34.6829 cubic inches		1.540 1151
1 gallon = 277.463 „		2.443 2051
1 gallon = 0.16057 cubic foot		1.205 6614
Cubic inches × 0.02883 = pints		2.459 8819
„ × 0.003604 = gallons		3.556 7949
Cubic feet × 6.228 = gallons		10.794 3386

* The grain is common to Avoirdupois, Troy, and Apothecaries' Weights.

† O = octarius, i.e., one eighth

‡ G = (Roman) Congius.

§ According to H. J. Chaney

One gallon once distilled water weighs 70000.5 grains.

„ twice „ „ „ 70000.0 „

„ well water weighs „ 70000.6 „

WEIGHTS AND MEASURES.*

WEIGHTS AND MEASURES—continued.

Long Measure.

12 inches	= 1 foot	4 poles	= 1 chain
3 feet	= 1 yard	10 poles	= 1 furlong
6 feet	= 1 fathom	8 furlongs	= 1 mile = 1760 yards
5½ yards	= 1 rod, pole, or perch.		

Square Measure.

144 square inches	= 1 square foot		
9 "	feet	1 "	yard
36½ "	yards	1 "	rod, pole, or perch
10 "	poles	1 rod	
	1 rod	1 acre	= 1840 square yards
640 ac			= 1 square mile

Cubic or Solid Measure.

1728 cubic inches	= 1 cubic foot	log 1728 = 3.237 5437
27 " " "	= 1 " yard	log 27 = 1.431 3638
		Logarithms.
1 cubic inch of water* at 62 F.	weighs 252.286 grains	= 2.401 8931
" " "	" 357.665 oz. (av.)	= 1.760 9150
" " "	" 0.036011 lb.	= 2.556 7951
1 cubic foot	" 996.335 oz. (av.)	= 2.998 1567
" " "	" 62.2784 lb.	= 1.794 3388
" " "	" 28.3191 kilograms	= 1.451 0046
1 cubic yard	" 0.75668 tons †	= 1.879 1116

Measures of Capacity.

4 gills	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 gallon

Ale, Beer, and Pot Still Measure.

The following measures between square brackets, though in common use, are not officially recognized —

4 gills	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 gallon
10 gallons	= 1 hikin
2 hikins	= 1 kilderkin = 18 gallons
2 kilderkins	= 1 barrel
3 "	= 1 mogshead
3 hogheads	= 1 butt

Dry Measure.

2 pints	= 1 quart	4 pecks	= 1 bushel
4 quarts	= 1 gallon	8 bushels	= 1 quarter
2 gallons	= 1 peck	4 quarters	= 1 chaldron

* *i.e.*, distilled water freed from air.

† One ton of water (224 gallons) occupies 35.967 cubic feet (log 1.55391).

WEIGHTS AND MEASURES—continued.

II. WEIGHTS AND MEASURES OF THE METRIC SYSTEM.

Measures of Weight.

The metric standard of weight is the kilogram, which is represented by a certain iridio-platinum weight deposited with the Board of Trade.

One-thousandth part of this is the gram which constitutes the *practical* unit of weight, the fractions and multiples of which are thus designated:—

0.1	gram = 1 decigram	10	grams = 1 dekagram
0.01	.. = 1 centigram	100	.. = 1 hectogram
0.001	.. = 1 milligram	1000	.. = 1 kilogram

Measures of Capacity.

* The standard litre is the volume of a kilogram of pure water at 4° C., under standard barometric pressure.

The value of the litre in terms of the cubic centimetre has been the subject of numerous experiments. Very exact measurements made during the last few years have shown that

1 litre = 1000.028 cubic centimetres (c.c., c. cm., or cm³.)

Hence in all but the most refined experiments the volume of one cubic centimetre may be taken as one-thousandth part of that of the litre (i.e. one millilitre or ml[†]).

1 decilitre = 100 c.c., 1 centilitre = 10 c.c.

Measures of Length.

The metre is represented by the length, at 0° C., of a certain iridio-platinum bar deposited with the Board of Trade. The fractions and multiples are as follows:—

0.1	metre = 1 decimetre (dm.)	10	metres = 1 dekametre
0.01	.. = 1 centimetre (cm.)	100	.. = 1 hectometre
0.001	.. = 1 millimetre (mm.)	1000	.. = 1 kilometre
0.001 mm.	= 1 micron (μ)	0.000004 inch	(nearly).
0.000001 mm.	= 1 micromillimetre ($\mu\mu$)	= 0.00000004 inch	(nearly).

TABLES FOR THE CONVERSION OF METRIC INTO IMPERIAL
MEASURES AND *vice versa*.A. *Linear Measure.*

Metric into Imperial.		Logarithms.
1 millimetre (mm.)	= 0.0393701 inches	2.595 1666
1 centimetre (cm.)	= 0.393701 ..	1.595 1666
1 decimetre (dm.)	= 3.937011 ..	0.595 1666
1 metre (m.)	= 39.370113 ..	1.595 1666
..	= 3.280843 feet	0.515 0855
..	= 1.093611 yards	0.038 8642
1 kilometre (km.)	= 1093.6126 ..	3.038 8612
..	= 0.621372 mile	1.793 3517

* 33 cm. = 13 inches within 0.008 inch in deficiency.

127 cm. = 50 inches within 0.00005 inch in excess.

† For pharmaceutical purposes the terms mil (millilitre), decimil (0.1 mil) and centimil (0.01 mil) have been legalized and are in regular use.

‡ The prefix *micro* always indicates a millionth part of the unit.

WEIGHTS AND MEASURES—continued.

Imperial into Metric				Logarithms
1 inch	=	2·540 centimetres	.	0·401 8337
1 foot	=	30·480 ..	.	1·484 0150
1 yard	=	0·914399 metre	.	1·961 1357
1 mile	=	1 609·3 kilometres	.	0·206 6370
1613 metres = 1761 yards, within 0·008 inch in deficiency.				

mm	inch	Metres	Feet	Inches	mm	metres
1	0·03937	1	3·2808	1	25·4	1·03014
2	0·07874	2	6·5616	2	50·8	2·06029
3	0·11811	3	9·8424	3	76·2	3·09044
4	0·15748	4	13·1232	4	101·6	4·12059
5	0·19685	5	16·4040	5	127·0	5·15074
6	0·23622	6	19·6848	6	152·4	6·18089
7	0·27559	7	22·9656	7	177·8	7·21104
8	0·31496	8	26·2464	8	203·2	8·24119
9	0·35433	9	29·5272	9	228·6	9·27134

B. Square Measure.

Metric into Imperial				Logarithms
1 square decimetre (dm ²)	=	15·50 square inches	.	1·190 3317
1 square metre (m ²) or cent are	=	107·639 square feet	.	1·031 9697
"	=	1·1960 square yards	.	0·077 7312
1 are (100 square metres)	=	119·60 ..	.	2·077 7112
"	=	0·021711 acres	.	2·392 8903

Imperial into Metric			
1 square inch	=	6·4516 square centimetres	0·809 6674
1 square foot	=	9·2903 square decimetres	0·968 0297
1 square yard	=	0·836126 square metres	1·922 2717
1 acre	=	0·15625 hectare	1·807 1117
1 square mile (640 acres)	=	259·00 hectares	2·413 2998

C. Cubic Measure and Measures of Capacity.

Metric into Imperial, etc.			
1 cubic centimetre (c.c.)	=	0·0610 cubic inch	2·785 3298
"	=	16·894 minims	1·227 7325
"	=	0·28167 fluid drachm	1·149 5864
"	=	0·035196 fluid ounce	2·546 4933
1 litre	=	61·024 cubic inches	1·785 5007
"	=	35·1960 fluid ounces	1·546 1933
"	=	1·75980 pints	0·245 4633
"	=	0·2200 gallon	1·342 4227
1 hectolitre	=	2·77 bushels	0·439 3327
1 cubic metre (m ³)	=	35·3148 cubic feet	1·547 9567
"	=	1·367954 cubic yards	0·116 5924

* 25 litres = 44 pints within 0·005 pint in deficiency.

5 dekalitres = 11 gallons within 0·002 gallon in deficiency.

WEIGHTS AND MEASURES—continued.

c.c. Cubic Inch.	Litres.	Fluid Ounces.	Pints.	Gallons.
1 = 0.061021	1 = 35.1960	1.7598	0.22	
2 = 0.122048	2 = 70.3920	3.5196	0.44	
3 = 0.183072	3 = 105.5880	5.2794	0.66	
4 = 0.244096	4 = 140.7840	7.0392	0.88	
5 = 0.305120	5 = 175.9800	8.7990	1.10	
6 = 0.366144	6 = 211.1760	10.5588	1.32	
7 = 0.427168	7 = 246.3720	12.3186	1.54	
8 = 0.488192	8 = 281.5680	14.0784	1.76	
9 = 0.549216	9 = 316.7640	15.8382	1.98	

	Imperial into Metric.	Logarithms.
1 cubic inch	16.387 cubic centimetres	1.214 4995
1 cubic foot	28.317 cubic decimetres	1.451 0172
1 cubic yard	0.764555 cubic metre	1.883 4076

1 minim	= 0.059 cubic centimetre	2.770 8520
1 fluid dram	= 3.552 cubic centimetres	0.550 1730
1 fluid ounce	= 28.4123 "	1.453 5064
1 pint	= 568.25 "	2.751 5394
1 quart	= 1.13649 litres	0.055 5655
1 gallon	= 4.5459631 litres	0.657 6260

Cubic Inches	Cubic Centimetres	Fluid Ounces	Cubic Centimetres
1 = 16.387		1 = 28.1123	
2 = 32.774		2 = 56.2246	
3 = 49.161		3 = 84.3369	
4 = 65.548		4 = 112.4492	
5 = 81.935		5 = 140.5615	
6 = 98.322		6 = 170.4738	
7 = 114.709		7 = 198.8861	
8 = 131.096		8 = 227.2984	
9 = 147.483		9 = 255.7107	

Pints.	Litres.	Gallons.	Litres.
1 = 0.56825		1 = 4.54596	
2 = 1.13650		2 = 9.09192	
3 = 1.70475		3 = 13.63788	
4 = 2.27300		4 = 18.18384	
5 = 2.84125		5 = 22.72980	
6 = 3.40950		6 = 27.27576	
7 = 3.97775		7 = 31.82172	
8 = 4.54600		8 = 36.36768	
9 = 5.11425		9 = 40.91364	

Note.—The following measure, though not recognized officially, is much used in certain trades:—1 barn gallon = 17 pints = 9.6602 litres.

WEIGHTS AND MEASURES—*continued*.

Metric into Imperial.		Logarithms.
1 milligram =	0.01543 grain	2.188 1324
1 centigram =	0.15432 grain	1.188 1324
1 decigram =	1.54324 grains	0.188 1324
1 gram =	15.4324 grains	1.188 4324
"	0.564383 dram avoirdupois	1.751 5739
"	0.035274 ounce avoirdupois	2.547 1347
"	0.25721 drachm apothecary	1.116 8878
"	0.0321507 ounce troy	2.467 1905
1 kilogram =	15432.3561 grains	4.188 4324
"	5.2740 ounces avoirdupois	1.517 1511
"	2.2046223 lb	0.513 3311
"	32.16074 ounces troy	1.507 1910
1 quintal 100 kilog. =	1.96 cwt.	0.294 025
1 tonne (1000 kilog. =	0.9842 ton	1.993 083

Grams.	Grains.	Oz. (Av.)	Oz. (Troy)	Kilograms.	Pounds
1 =	15.43236 =	0.035274 =	0.0321507 =	1 =	2.204622
2 =	30.86472 =	0.070548 =	0.0643014 =	2 =	4.409244
3 =	46.29708 =	0.105822 =	0.0964521 =	3 =	6.613866
4 =	61.72944 =	0.141096 =	0.1286028 =	4 =	8.818488
5 =	77.16180 =	0.176370 =	0.1607535 =	5 =	11.023110
6 =	92.59416 =	0.211644 =	0.1929042 =	6 =	13.227732
7 =	108.02652 =	0.246918 =	0.2250549 =	7 =	15.432354
8 =	123.45888 =	0.282192 =	0.2572056 =	8 =	17.636976
9 =	138.89124 =	0.317466 =	0.2893563 =	9 =	19.841598

Imperial into Metric.		Logarithms.
1 grain =	0.0648 gram	2.811 5750
1 drachm (apoth.) =	3.888 grams	0.589 2363
1 ounce troy =	31.1035 grams	1.492 8093
1 dram avoirdupois =	1.772 grams	0.248 1437
1 ounce avoirdupois =	28.350 grams	1.452 5531
1 pound (16 oz.) =	453.59213 grams	2.656 6558
1 stone (14 lb.) =	6.350 kilogram	0.805 7737
1 quarter (28 lb.) =	12.70 kilograms	1.106 8037
1 cwt. (112 lb.) =	50.80 kilograms	1.705 8637
"	0.5080 quintal	1.705 8637
1 ton (20 cwt.) =	1016.0 kilograms	3.006 8937

Grams.	Gram.	Ounce* (Av.)	Grains.
1 =	0.06480	1 =	28.35
2 =	0.12960	2 =	56.70
3 =	0.19440	3 =	85.05
4 =	0.25920	4 =	113.40
5 =	0.32399	5 =	141.75
6 =	0.38879	6 =	170.10
7 =	0.45359	7 =	198.45
8 =	0.51839	8 =	226.80
9 =	0.58319	9 =	255.15

41 kilograms = 97 pounds within 0.001 lb. in excess.

303 " = 668 " " 0.0006 lb. " "

* The "short ton" 2000 lb. is occasionally used both in this country and in America. In contradistinction the ton of 2240 lb. is called the "long ton."

WEIGHTS AND MEASURES—*continued*.

Pounds to Kilograms.		Hundredweights to Kilograms
1 = 0.45359	}	1 = 50.8
2 = 0.90718		2 = 101.6
3 = 1.36077		3 = 152.4
4 = 1.81436		4 = 203.2
5 = 2.26795		5 = 254.0
6 = 2.72154		6 = 304.8
7 = 3.17513		7 = 355.6
8 = 3.62872		8 = 406.4
9 = 4.08231		9 = 457.2

Ex. How many grams are equivalent to 30 ounces (av.)?

$$30 \times 850.5$$

$$= 25515$$

11056.6 grams.

BRITISH AND UNITED STATES WEIGHTS AND MEASURES.

British	United States.
Standard yard at 62° F.	standard yard at 59° F.
1 lb.	1 lb.
1 gallon.	1.2 gallon.
1 " = 1 " (3.7853 litres).	

cubic feet	7.4733	U.S. gallons.
cubic inches	$\times 0.00433$	

In the drug trade two large bottles are used:

Corbyn	40 fluid oz. (quart).
Winchester	80 " ($\frac{1}{2}$ gallon).

85 minims	5 c.c.	1 teaspoonful.
255 "	15 c.c.	2 tablespoonful.

FOREIGN WEIGHTS AND THEIR ENGLISH EQUIVALENTS.

The Metric System is compulsory in Austria, Belgium, France, Germany, Greece, Italy, Luxembourg, the Netherlands, Portugal, Rumania, Spain, Switzerland, Turkey, and most of the South American Republics; optional in Great Britain, the United States, and Russia.

China	Tael weight	155 oz.
	Catty	16 tael = 133 lb.
	Pien	133.33 lb.
Egypt	Oke	206 lb.
	78 okes	160 kilol.
	Candari	121.36 lb.
Japan	Le pooka-ha	57.96 gallons.
	Sho	1.881 quart.
	Dry koka	3626 bushels
	Sho	6.355 pecks.
	Kwan	8.267 lb.
	Kim	1.328 lb.
Russia	Pood	35.23 lb.
	Funt	1 pood = 36.11 lb.
Turkey	Oke	100 dram = 28.36 lb.
	Kanta	121.36 lb.
	78 okes	160 kilol. = 220.46 h.
Greece	Loque	2.84 lb. 1 livre = 1.1 lb.
	Quinad	132.2 lb. 1 drachme = 0.11 oz.

TABLE SHOWING THE SIGNS USED IN WRITING MEDICAL PRESCRIPTIONS.

$\frac{1}{2}$ grain	$\frac{1}{2}$ gr.	1 drachm	5 i. or 5 j.
1 "	gr. i. or gr. i.	14 "	ss.
14 "	gr. iiss.	2 drachms	ii. or 5 ij.
2 grains	gr. ii. or gr. ij.	3 "	iii. or 5 iij.
24 "	gr. iiss.	31 "	viiss.
4 "	gr. iv.	71 "	viiiss.
8 "	gr. viii. or gr. viij.	1 ounce	viiss.
$\frac{1}{2}$ scruple	ss.	1 "	i. or 3 j.
1 "	ss. i. or 3 j.	15 "	ss.
14 "	ss.	$\frac{1}{2}$ pint	Oss.
2 scruples	ss. ii. or 6 ij.	1 "	O.

DENSITIES OF ELEMENTS AND COMMON SUBSTANCES
(LIQUIDS AT 15° C.)

Agate	2.6	Cobalt	8.6
Aluminium	2.7	Coke	1.0-1.7
Aluminium bronze	8	Copper	8.93
Außer	1.1	Cork	0.22-0.26
Amphibole	2.9-3.1	Diamond	3.52
Anhydrite	2.98	Dolomite	2.9
Anthracite	1.35-1.7	Ebonite	1.8
Antimony	6.62	Ebony	1.2
Apatite	3.3	Elm (dry)	0.59
Araggonite	3	Emery	4
Arsenic	5.73	Fel spar	2.4-2.6
Ash	0.6-8	Fir (Riga) dry	0.75
Bamboo	0.4	Fluor spar	3.2
Basalt	2.8	Galena	7.6
Beech wood	0.69-8	Gaucauon	1.9
Beeswax	0.96	German silver	8.5-8.9
Bismuth	9.8	Glass (crown)	2.5
Bitumen	0.8-1.2	„ (flint)	2.9-3.25
Box-wood	0.9-1.1	„ (Bohemian)	2.4
Bone	1.8-2	Glycerin	1.26
Brass	8.4-8.7	Gold	19.32
Brick	2.1	„ (18 carat)	14.88
Bromine	3.1	„ (comage (British))	17.18*
Bronze cogage	8.66	Granite	2.5-3
Cadmium	8.61	Graphite	2.3
Calamine	3.1	Gun metal	8-8.1
Calc-spar	2.7	Gutta percha	0.97
Cedar	0.5-6	Gypsum	2.3
Celluloid	1.4	Heavy spar	4.5
Chalk (mean)	2.3	Hæmatite	5
Charcoal (wood)	0.3-5	Ic (at 0)	0.9168
Chloroform	1.5	Iceland Spar	2.7
Chrome alum	1.83	India rubber	0.91-0.93
Chromium	6.5	Iodine	4.95
Cinnabar	8.1	Iron (cast)	7.1-7.7
Coal	1.2-1.5	„ (wrought)	7.8-7.9

* These values were kindly supplied to the author by Dr. T. K. Rose, Chemist to the Royal Mint.

DENSITIES OF COMMON SUBSTANCES.

65

Ivory	1.8-1.9	Sea-water	1.026
Lead	11.37	Selenite	2.3
Lime	3.2	Serpentine	2.6
Lithium	0.534	Shale	2.5
Magnesium	1.74	Silica (fused) :-	
Mahogany	56.85	" (transparent)	2.21
Manganese	7.39	" (translucent)	2.07
Marble	2.5-2.8	Silicon	2.3
Mercury	13.56	Silver	10.5
Methylated spirit	0.83	" coinage (British) 10.35-10.38*	
Mica	2.7-3.1	Slate	2.1-2.8
Milk (cows')	1.03	Sodium	0.97
Molybdenum	10.0	Spermaceti	0.91
Nickel	8.9	Steel	7.7-7.9
Oak (English)	0.93	Strontianite	3.6
Osmium	22.5	Strontium	2.54
Palladium	11.4	Sugar (cane)	1.6
Petrol	0.68-0.72	Sulphur (rhombic)	2.07
Phosphor bronze	8.7-8.9	Talc	2.5
Phosphorus (yellow)	1.81	Teak (Indian)	0.7-0.9
" (red)	2.2	Tin	7.29
Pine-wood	0.56	Tinstone	6.9
Platinum	21.5	Turpentine	0.87
Potassium	0.862	Vanadium	5.5
Pumice-stone	0.4-0.9	Willow-wood	0.4
Pyrites (iron)	5	Witherite	4.3
Pyrolusite	4.9	Wool	1.6
Quartz	2.66	Zinc	7.1
Sand (silver)	2.63	Zinc blende	4.16

* These values were kindly supplied to the author by Dr. T. K. Rose, Chemist to the Royal Mint.

TABLE FOR THE CONVERSION OF DRAMS PER LB. INTO PERCENTAGE AND INTO LB. PER TON.

Drams per lb. (av.)	Per cent.	Lb. per ton (2240 lb.)	Drams per lb. (av.)	Per cent.	Lb. per ton (2240 lb.)
$\frac{1}{2}$	0.097656	2.137494	31	1.405	31.81
$\frac{1}{4}$	(or 0.1 nearly)		4	1.562	35.00
$\frac{1}{8}$	.195	4.37	$\frac{1}{2}$	1.700	37.19
$\frac{1}{16}$	.293	6.60	$\frac{3}{4}$	1.758	39.38
$\frac{1}{32}$	.390625	8.75	$\frac{1}{4}$	1.855	41.56
$\frac{1}{64}$	.488	10.94	5	1.953	43.75
$\frac{1}{128}$	.586	13.12	10	3.906	87.50
$\frac{1}{256}$	.683	15.31	15	5.859	131.25
$\frac{1}{512}$	.781	17.50	20	7.812	175.00
$\frac{1}{1024}$	.879	19.68	25	9.765	218.75
$\frac{1}{2048}$	.976	21.87	30	11.719	262.50
$\frac{1}{4096}$	1.074	24.06	35	13.672	306.25
$\frac{1}{8192}$	1.172	26.25	40	15.625	350.00
$\frac{1}{16384}$	1.269	28.43	45	17.578	393.75
$\frac{1}{32768}$	1.367	30.62	50	19.531	437.50

* Log. 1.50176.

† Log. 0.94200.

TABLE FOR THE CONVERSION OF PERCENTAGE INTO
CWTs., QRS., AND LB. PER TON, AND INTO QRS. AND LB. PER CWT.

Per cent.	Per ton.			Per cent.	Per cent.	Per ton.			Per cwt.	
	cwt.	qrs.	lb.			cwt.	qrs.	lb.	qrs.	lb.
1	..	..	22.4	..	..	1	..	22.4	2	11.2
2	..	1	16.8	..	..	2	1	16.8	2	8.4
3	..	2	11.2	..	..	3	2	11.2	2	5.6
4	..	3	5.6	..	..	4	3	5.6	2	2.8
5	1	..	..	..	..	5	..	..	2	1.4
6	1	1	22.4	..	..	6	1	22.4	2	11.2
7	1	1	16.8	..	..	7	1	16.8	2	8.4
8	1	2	11.2	..	..	8	2	11.2	2	5.6
9	1	3	5.6	..	..	9	3	5.6	2	2.8
10	2	..	..	..	..	10	..	..	2	1.4
11	2	1	22.4	..	..	11	1	22.4	2	11.2
12	2	1	16.8	..	..	12	1	16.8	2	8.4
13	2	2	11.2	..	..	13	2	11.2	2	5.6
14	2	3	5.6	..	..	14	3	5.6	2	2.8
15	3	..	..	..	..	15	..	..	2	1.4
16	3	1	22.4	..	..	16	1	22.4	2	11.2
17	3	1	16.8	..	..	17	1	16.8	2	8.4
18	3	2	11.2	..	..	18	2	11.2	2	5.6
19	3	3	5.6	..	..	19	3	5.6	2	2.8
20	4	..	..	..	..	20	..	..	2	1.4
21	4	1	22.4	..	..	21	1	22.4	2	11.2
22	4	1	16.8	..	..	22	1	16.8	2	8.4
23	4	2	11.2	..	..	23	2	11.2	2	5.6
24	4	3	5.6	..	..	24	3	5.6	2	2.8
25	5	..	..	..	..	25	..	..	2	1.4
26	5	1	22.4	..	..	26	1	22.4	2	11.2
27	5	1	16.8	..	..	27	1	16.8	2	8.4
28	5	2	11.2	..	..	28	2	11.2	2	5.6
29	5	3	5.6	..	..	29	3	5.6	2	2.8
30	6	..	..	..	..	30	..	..	2	1.4
31	6	1	22.4	..	..	31	1	22.4	2	11.2
32	6	1	16.8	..	..	32	1	16.8	2	8.4
33	6	2	11.2	..	..	33	2	11.2	2	5.6
34	6	3	5.6	..	..	34	3	5.6	2	2.8
35	7	..	..	..	..	35	..	..	2	1.4
36	7	1	22.4	..	..	36	1	22.4	2	11.2
37	7	1	16.8	..	..	37	1	16.8	2	8.4
38	7	2	11.2	..	..	38	2	11.2	2	5.6
39	7	3	5.6	..	..	39	3	5.6	2	2.8
40	8	..	..	..	..	40	..	..	2	1.4
41	8	1	22.4	..	..	41	1	22.4	2	11.2
42	8	1	16.8	..	..	42	1	16.8	2	8.4
43	8	2	11.2	..	..	43	2	11.2	2	5.6
44	8	3	5.6	..	..	44	3	5.6	2	2.8
45	9	..	..	..	..	45	..	..	2	1.4
46	9	1	22.4	..	..	46	1	22.4	2	11.2
47	9	1	16.8	..	..	47	1	16.8	2	8.4
48	9	2	11.2	..	..	48	2	11.2	2	5.6
49	9	3	5.6	..	..	49	3	5.6	2	2.8
50	10	..	..	..	..	50	..	..	2	1.4

Per cent.	1	2	3	4	5	6	7	8	9
lb. per cwt.	11.2	22.4	33.6	44.8	56	67.2	78.4	89.6	100.8
lb. per ton	22.4	44.8	67.2	89.6	112	134.4	156.8	179.2	201.6

THE BAROMETRE.

I. *Inches into Millimetres.*

Inches.	Milli- metres.	Inches.	Milli- metres.	Inches.	Milli- metres.	Inches.	Milli- metres.			
27.5	698.49	28.1	711.35	29.3	744.21	30.2	766.97			
26	701.03	5	723.89	4	746.75	2	769.61			
27	703.57	6	726.43	5	749.29	4	772.15			
28	706.11	7	728.97	6	751.83	5	774.69			
29	708.65	8	731.51	7	754.37	6	777.23			
28.0	711.19	9	734.05	8	756.91	7	779.77			
1	713.73	29.0	736.59	9	759.45	8	782.31			
2	716.27	1	739.13	30.0	761.99	9	784.85			
3	718.81	2	741.67	1	764.53					
Inches.		.01	.02	.03	.04	.05	.06	.07	.08	.09
Millimetres,		25	51	76	102	127	152	177	203	229

II. *Millimetres into Inches.*

Min.	Inches	Min.	Inches	Min.	Inches	Min.	Inches	Min.	Inches
700	27.56	715	28.27	735	28.94	752	29.61	770	30.28
701	27.60	719	28.31	736	28.98	753	29.65	771	30.32
702	27.64	720	28.35	737	29.02	754	29.69	772	30.36
703	27.68	721	28.39	738	29.06	755	29.73	773	30.39
704	27.72	722	28.43	739	29.10	756	29.76	774	30.43
705	27.76	723	28.47	740	29.13	757	29.80	775	30.47
706	27.80	724	28.50	741	29.17	758	29.84	776	30.51
707	27.81	725	28.54	742	29.21	759	29.88	776	30.55
708	27.88	726	28.58	743	29.25	760	29.92	777	30.59
709	27.91	727	28.62	744	29.29	761	29.96	778	30.63
710	27.95	728	28.66	745	29.33	762	30.00	779	30.67
711	27.99	729	28.70	746	29.37	763	30.04	780	30.71
712	28.03	730	28.74	747	29.41	764	30.08	781	30.75
713	28.07	781	28.78	748	29.45	765	30.12	782	30.79
714	28.11	782	28.82	749	29.49	766	30.16	783	30.83
715	28.15	783	28.86	750	29.53	767	30.20	784	30.87
716	28.19	784	28.90	751	29.57	768	30.24	785	30.91
717	28.23								

TABLE FOR CORRECTION OF VOLUMES OF GASES FOR TEMPERATURE,
GIVING THE DIVISOR FOR THE FORMULA.

$$V^t = \frac{V \times B}{760 \times (1 + \delta t)} \quad \delta = .003665$$

t	760 (1 + δt)	Log. [760 x (1 + δt)]	t	760 (1 + δt)	Log. [760 x (1 + δt)]
0.0	760.0000	2.8808175	4.0	771.4416	2.8871311
.1	760.2785	9727	.1	771.4901	2909
.2	760.5571	2.8811318	.2	771.6987	4477
.3	760.8356	2908	.3	771.9772	6045
.4	761.1142	4495	.4	772.2558	7612
.5	761.3927	6087	.5	772.5343	9178
.6	761.6712	7675	.6	772.8128	2.8880743
.7	761.9498	9263	.7	773.0914	2308
.8	762.2283	2.8820850	.8	773.3699	3872
.9	762.5069	2157	.9	773.6485	5436
1.0	762.7854	2.8824021	5.0	773.9270	2.8887000
.1	763.0639	3610	.1	774.2055	8563
.2	763.3425	7195	.2	774.4841	2.8890125
.3	763.6210	8779	.3	774.7626	1687
.4	763.8996	2.8826363	.4	775.0412	3248
.5	764.1781	1916	.5	775.3197	4808
.6	764.4566	3528	.6	775.5982	6368
.7	764.7352	5111	.7	775.8768	7927
.8	765.0137	6692	.8	776.1553	9486
.9	765.2923	8273	.9	776.4339	2.8901044
2.0	765.5708	2.8839854	6.0	776.7124	2.8902602
.1	765.8493	2.8841434	.1	776.9909	4159
.2	766.1279	3013	.2	777.2695	5716
.3	766.4064	4591	.3	777.5480	7272
.4	766.6850	6169	.4	777.8266	8828
.5	766.9635	7747	.5	778.1051	2.8910383
.6	767.2420	2.8849324	.6	778.3836	1938
.7	767.5206	2.8850901	.7	778.6622	3492
.8	767.7991	2477	.8	778.9407	5045
.9	768.0777	4052	.9	779.2193	6597
3.0	768.3562	2.8855626	7.0	779.4978	2.8918149
.1	768.6347	7199	.1	779.7763	9701
.2	768.9133	8772	.2	780.0549	2.8921252
.3	769.1918	2.8860345	.3	780.3334	2802
.4	769.4704	1918	.4	780.6120	4352
.5	769.7489	3490	.5	780.8905	5901
.6	770.0274	5062	.6	781.1690	7450
.7	770.3060	6633	.7	781.4476	8998
.8	770.5845	8203	.8	781.7261	2.8930546
.9	770.8631	9772	.9	782.0047	2093

TABLE FOR CORRECTION OF VOLUMES OF GASES *continued*.

t	$760 \times$ (1 + δt).	Log. [760 \times] (1 + δt).	t	$760 \times$ (1 + δt).	Log. [760 \times] (1 + δt).
8.0	782.2832	2.8933640	12.0	791.8176	2.9002674
1	782.5617	5186	1	795.0960	1196
2	782.8403	6732	2	795.3746	5747
3	783.1188	8277	3	795.6531	7238
4	783.3974	9821	4	795.9317	8758
5	783.6759	2.8941365	5.0	796.2102	2.9010277
6	783.9544	2968	6	796.4887	1496
7	784.2330	4451	7	796.7673	3315
8	784.5115	5993	8	797.0458	4823
9	784.7901	7555	9	797.3244	6350
9.0	785.0686	2.8949076	10.0	797.6029	7867
1	785.3471	2.8956617	1	797.8814	9384
2	785.6257	4157	2	798.1600	2.9020900
3	785.9042	3697	3	798.4385	2415
4	786.1828	5236	4	798.7171	3930
5	786.4613	6774	5.0	798.9956	2.9025144
6	786.7398	8311	6	799.2741	6957
7	787.0184	9848	7	799.5527	8470
8	787.2969	2.8961385	8	799.8312	9983
9	787.5755	1321	9	800.1098	2.9031495
10.0	787.8540	2.8961457	10.0	800.3883	2.9033007
1	788.1325	5993	1	800.6668	4518
2	788.4111	7528	2	800.9454	6029
3	788.6896	9062	3	801.2239	7539
4	788.9682	2.8970595	4	801.5025	9049
5	789.2467	2128	5.0	801.7810	2.9040558
6	789.5252	3660	6	802.0595	2066
7	789.8038	5192	7	802.3381	3574
8	790.0823	6724	8	802.6166	5081
9	790.3609	8251	9	802.8952	6588
10.0	790.6394	2.8979784	10.0	803.1737	8095
1	790.9179	2.8981314	1	803.4523	9601
2	791.1965	2843	2	803.7308	2.9051106
3	791.4750	4372	3	804.0093	2611
4	791.7536	2.8985900	4	804.2879	4115
5	792.0321	7428	5.0	804.5664	2.9055619
6	792.3106	8955	6	804.8449	7122
7	792.5892	2.8990482	7	805.1235	8625
8	792.8677	2008	8	805.4020	2.9060127
9	793.1463	3533	9	805.6806	1628
10.0	793.4248	2.8995058	10.0	805.9591	2.9063129
1	793.7033	6582	1	806.2376	4630
2	793.9819	8106	2	806.5162	6130
3	794.2604	9629	3	806.7947	7630
4	794.5390	2.9001152	4	807.0733	9129

TABLE FOR CORRECTION OF VOLUMES OF GASES *continued*.

t	760 x (1+ δt).	Log. [760 x (1+ δt)]	t	760 x (1+ δt).	Log. [760 x (1+ δt)]
17.0	807.3518	2.907062	21.5	819.8861	2.9137535
1	807.6393	21.6	6	820.1616	9010
2	807.9089	36.24	7	820.4432	2.9140485
3	808.1874	51.21	8	820.7217	1960
4	808.4660	66.18	9	821.0003	3434
17.5	808.7415	81.14	22.0	821.2788	2.9143407
6	809.0230	2.9079609	1	821.5573	6380
7	809.3016	2.9081104	2	821.8359	7852
8	809.5801	2598	3	822.1144	9323
9	809.8587	1092	4	822.3930	2.9150794
18.0	810.1372	2.9085586	22.5	822.6715	2265
1	810.4175	7079	6	822.9500	3735
2	810.6943	8571	7	823.2286	5205
3	810.9728	2.9090063	8	823.5071	6674
4	811.2514	1554	9	823.7857	8148
18.5	811.5299	3045	23.0	824.0642	2.9159611
6	811.8084	4535	1	824.3427	2.9161079
7	812.0870	6025	2	824.6213	2546
8	812.3655	7515	3	824.8998	4013
9	812.6441	9004	4	825.1781	5479
19.0	812.9226	2.9100192	23.5	825.4569	6945
1	813.2011	1980	6	825.7354	8410
2	813.4797	3467	7	826.0140	9875
3	813.7582	4954	8	826.2925	2.9171339
4	814.0368	6440	9	826.5711	2802
19.5	814.3153	7926	24.0	826.8496	2.9174265
6	814.5938	9411	1	827.1281	5728
7	814.8724	2.9110896	2	827.4067	7190
8	815.1509	2380	3	827.6852	8652
9	815.4295	3864	4	827.9638	2.9180114
20.0	815.7080	2.9115347	24.5	828.2423	1575
1	815.9865	6830	6	828.5208	3035
2	816.2651	8312	7	828.7991	4495
3	816.5436	9794	8	829.0779	5954
4	816.8222	2.9121275	9	829.3565	7412
20.5	817.1007	2756	25.0	829.6350	2.9188870
6	817.3792	4236	1	829.9135	2.9190388
7	817.6578	2.9123716	2	830.1921	1785
8	817.9363	7195	3	830.4706	3242
9	818.2149	8674	4	830.7492	4699
21.0	818.4934	2.9130152	25.5	831.0277	2.9186155
1	818.7719	1630	6	831.3062	7610
2	819.0505	3107	7	831.5848	9065
3	819.3280	4583	8	831.8633	2.9200520
4	819.6076	6059	9	832.1419	1974

TABLE FOR CORRECTION OF VOLUMES OF GASES—continued.

t	$760 \times$ (1 + δt).	Log. [760 \times (1 + δt)]	t	$760 \times$ (1 + δt).	Log. [760 \times (1 + δt)]
$^{\circ}\text{C.}$			$^{\circ}\text{C.}$		
26.0	832.4201	2.9203427	28.1	838.2637	2.9233838
1	832.6989	4880	2	838.5483	5281
2	832.9775	6393	3	838.8268	6723
3	833.2560	7785	4	839.1051	8165
4	833.5346	9247	28.5	839.3839	2.9239606
26.5	833.8131	2.9210688	6	839.6621	2.9241047
6	834.0916	2139	7	839.9410	2488
7	834.3702	3559	8	840.2195	3928
8	834.6487	5038	9	840.4981	5368
9	834.9273	6487	29.0	840.7766	2.9246807
27.0	835.2058	2.9217936	1	841.0551	8216
1	835.4843	9384	2	841.3337	9684
2	835.7629	2.9220832	3	841.6122	2.9251122
3	836.0414	2279	4	841.8908	2559
4	836.3200	3725	29.5	842.1693	3997
27.5	836.5985	5171	6	842.4478	5431
6	836.8770	6617	7	842.7264	6866
7	837.1556	8062	8	843.0049	8301
8	837.4341	9507	9	843.2835	9736
9	837.7127	2.9230951	30.0	843.5620	2.9261171
28.0	837.9912	2.9232395			

VAPOUR PRESSURE OF MERCURY.*

Temperature	Vapour Pressure	Temperature	Vapour Pressure
$^{\circ}\text{C.}$	mm.		mm.
0	.00016	60	.0246
5	.00026	80	.0885
10	.00043	100	.276
15	.00069	150	2.88
20	.00109	200	17.81
25	.00168	250	75.83
30	.00257	300	218.6
35	.00387	356.7	760
40	.00571	400	1566
50	.0122	450	3229

* * From observations by Ramsay and Young, Callendar and Griffiths, and others (values in mm. of mercury at 0°C.).

VOLUME AND DENSITY OF WATER AT DIFFERENT TEMPERATURES.*

Temp.	Sp. gr. of Water (at 0 = 1).	Vol. of Water (at 0 = 1).	Sp. gr. of Water (at 4° = 1).	Vol. of Water (at 4° = 1).
0°	1.000000	1.000000	.999871	1.0060129
1	1.000057	0.999943	.999928	1.000072
2	1.000098	.999902	.999969	1.000031
3	1.000120	.999880	.999991	1.000009
4	1.000129	.999871	1.000000	1.000000
5	1.000119	.999881	0.999990	1.000014
6	1.000099	.999901	.999970	1.000030
7	1.000062	.999938	.999933	1.000067
8	1.000015	.999985	.999886	1.000114
9	0.999953	1.000017	.999821	1.000176
10	.999876	1.000124	.999747	1.000253
11	.999784	1.000216	.999655	1.000315
12	.999678	1.000322	.999549	1.000351
13	.999559	1.000441	.999430	1.000370
14	.999429	1.000572	.999299	1.000371
15	.999289	1.000712	.999160	1.000341
16	.999131	1.000870	.999002	1.000299
17	.998950	1.001031	.998811	1.000160
18	.998782	1.001219	.998651	1.000134
19	.998638	1.001413	.998500	1.000112
20	.998508	1.001615	.998359	1.000144
21	.998376	1.001828	.998217	1.000197
22	.998253	1.002049	.998026	1.000277
23	.998130	1.002276	.997801	1.0002105
24	.997995	1.002511	.997567	1.002611
25	.997849	1.002759	.997320	1.002888
26	.997691	1.003011	.997066	1.003144
27	.997532	1.003278	.996803	1.003408
28	.997360	1.003553	.996531	1.003682
29	.997179	1.003835	.996251	1.003965
30	.996994	1.004123	.995965	1.004253
35	0.996131	1.00572	0.995118	1.00593
40	0.995218	1.00754	0.99235	1.00773
45	0.99050	1.00958	0.99037	1.00974
50	0.98832	1.01182	0.98819	1.01201
55	0.98564	1.01426	0.98581	1.01442
60	0.98350	1.01678	0.98338	1.01697
65	0.98086	1.01951	0.98074	1.01971
70	0.97807	1.02243	0.97794	1.02260
75	0.97511	1.02553	0.97498	1.02569
80	0.97206	1.02874	0.97194	1.02890
85	0.96892	1.03207	0.96879	1.03224
90	0.96568	1.03554	0.96556	1.03574
95	0.96231	1.03918	0.96219	1.03938
100	0.95879	1.04299	0.95866	1.04315

* This table may be utilized to reduce a sp. gr. taken with reference to water at one temperature to water at 4° C. Thus, let S_{10} be the sp. gr. of a substance referred to water at 10° C. as unity, then the sp. gr. (S_4) referred to water at 4° as unity will be $S_4 = S_{10} \times .99916 - S_{10}(1 - .00084)$.

* Rosettii.

BAUME'S HYDROMETER. *Table for Liquids heavier than Water.**

* B.	* Tw.	Sp. gr.	* B.	* Tw.	Sp. gr.	* B.	* Tw.	Sp. gr.
1	1.4	1.007	23	30	1.193	45	90.6	1.453
2	2.8	1.014	24	40	1.200	46	91.6	1.468
3	4.4	1.022	25	42	1.210	47	92.6	1.483
4	5.8	1.029	26	44	1.220	48	93.6	1.498
5	7.4	1.037	27	46.2	1.231	49	94.6	1.515
6	9	1.045	28	48.2	1.241	50	95.6	1.530
7	10.2	1.052	29	50.2	1.252	51	96.6	1.546
8	12	1.060	30	52.6	1.263	52	97.6	1.563
9	13.4	1.067	31	54.8	1.274	53	98.6	1.580
10	15	1.075	32	57	1.285	54	99.6	1.597
11	16.6	1.083	33	59.4	1.297	55	100	1.615
12	18.2	1.091	34	61.6	1.308	56	101	1.635
13	20	1.100	35	64	1.320	57	102.4	1.652
14	21.6	1.108	36	66.4	1.332	58	104.2	1.671
15	23.2	1.116	37	69	1.345	59	106.2	1.691
16	25	1.125	38	71.4	1.357	60	112	1.710
17	26.8	1.134	39	74	1.370	61	116.4	1.732
18	28.4	1.142	40	76.6	1.383	62	120.6	1.753
19	30.1	1.152	41	79.4	1.397	63	125	1.775
20	32.1	1.162	42	82	1.410	64	130	1.795
21	34.2	1.171	43	84.8	1.424	65	134	1.820
22	36	1.180	44	87.6	1.438	66	138.4	1.842

* This is the Baume's hydrometer mostly used on the Continent of Europe, but other series are in use there as well as elsewhere; the one for Baume's hydrometer is used in America (*Long's Technical Chemistry Handbook*).

Table for Liquids lighter than Water.

* B.	Sp. gr.	* B.	Sp. gr.	* B.	Sp. gr.
10	1.000	27	0.896	44	0.811
11	0.993	28	0.890	45	0.807
12	0.986	29	0.885	46	0.802
13	0.980	30	0.880	47	0.798
14	0.973	31	0.874	48	0.794
15	0.967	32	0.869	49	0.789
16	0.960	33	0.861	50	0.785
17	0.954	34	0.859	51	0.781
18	0.948	35	0.854	52	0.777
19	0.942	36	0.849	53	0.773
20	0.936	37	0.841	54	0.768
21	0.930	38	0.839	55	0.764
22	0.924	39	0.831	56	0.760
23	0.918	40	0.830	57	0.757
24	0.913	41	0.825	58	0.753
25	0.907	42	0.820	59	0.749
26	0.901	43	0.816	60	0.745

Twaddell's Hydrometer—To convert degrees Twaddell into specific gravity (water = 1000): multiply the number by 5, and add 0.000 to the product.

To reduce specific gravity (water = 1000) to Twaddell: deduct 1000, and divide the remainder by 5.

* * * Veley and Manley have given (see *Jour. Soc. Chem. Ind.*, 1903, pp. 1227-1921) a table of densities of nitric acid from 1.38, to 1.521, the results of which agree closely with those tabulated above.

* CORRECTIONS FOR 1° C. (212° WHEN ABOVE 15°, SUBTRACT WHEN BELOW 15° C.).

Sp. gr.	Correction.	Sp. gr.	Correction.
1.020-1.040	0.0002	1.251-1.310	0.0010
1.041-1.070	0.0003	1.311-1.350	0.0011
1.071-1.100	0.0004	1.351-1.365	0.0012
1.101-1.130	0.0005	1.366-1.400	0.0013
1.131-1.160	0.0006	1.401-1.435	0.0014
1.161-1.200	0.0007	1.436-1.490	0.0015
1.201-1.245	0.0008	1.491-1.500	0.0016
1.246-1.280	0.0009	1.501-1.520	0.0017

TABLE SHOWING THE STRENGTH OF SULPHURIC ACID OF DIFFERENT DENSITIES.*

Sp. gr. at 15° C.	H ₂ SO ₄ per cent.	Grams H ₂ SO ₄ per litre.	Sp. gr. at 15° C.	H ₂ SO ₄ per cent.	Grams H ₂ SO ₄ per litre.
1.010	1.28	15	1.340	35.71	586
1.020	2.47	31	1.350	36.58	605
1.030	3.67	46	1.360	37.45	624
1.040	4.87	62	1.370	38.32	643
1.050	6.07	77	1.380	39.18	662
1.060	7.16	93	1.390	40.05	682
1.070	8.32	109	1.400	40.94	702
1.080	9.47	125	1.410	41.76	721
1.090	10.60	142	1.420	42.57	740
1.100	11.71	158	1.430	43.36	759
1.110	12.82	175	1.440	44.14	779
1.120	13.92	190	1.450	44.92	798
1.130	14.95	207	1.460	45.69	817
1.140	16.01	223	1.470	46.45	837
1.150	17.07	239	1.480	47.21	856
1.160	18.11	257	1.490	47.95	876
1.170	19.16	275	1.500	48.73	896
1.180	20.21	292	1.510	49.51	916
1.190	21.26	310	1.520	50.28	936
1.200	22.30	328	1.530	51.04	957
1.210	23.33	346	1.540	51.78	977
1.220	24.36	364	1.550	52.46	996
1.230	25.39	382	1.560	53.22	1017
1.240	26.35	400	1.570	53.95	1038
1.250	27.29	418	1.580	54.65	1058
1.260	28.22	435	1.590	55.37	1078
1.270	29.15	454	1.600	56.09	1099
1.280	30.10	472	1.610	56.79	1120
1.290	31.04	490	1.620	57.49	1141
1.300	31.99	510	1.630	58.18	1162
1.310	32.91	529	1.640	58.88	1182
1.320	33.88	548	1.650	59.57	1204
1.330	34.80	567	1.660	60.26	1225

* The above table is taken from Lunge's *Technical Chemists' Handbook* (second edition, 1916) and embodies his latest corrections. It differs in parts from the table by Lunge, Isler and Naef.

TABLE SHOWING THE STRENGTH OF SULPHURIC ACID OF DIFFERENT DENSITIES—*continued*.

Sp. gr. at 15°/15° C.	SO ₃ per cent.	H ₂ SO ₄ per cent.	Grams H ₂ SO ₄ per litre.	Sp. gr. at 15°/15° C.	SO ₃ per cent.	H ₂ SO ₄ per cent.	Grams H ₂ SO ₄ per litre.
1.670	60.95	74.66	1216	1.780	68.98	81.50	1504
1.680	61.65	75.50	1268	1.790	69.96	82.70	1534
1.690	62.39	76.30	1289	1.800	70.96	83.92	1565
1.700	63.00	77.17	1312	1.810	72.08	85.30	1598
1.710	63.70	78.04	1331	1.820	73.51	86.95	1639
1.720	64.43	78.92	1357	1.825	74.29	87.00	1661
1.730	65.11	79.80	1381	1.830	75.19	88.16	1685
1.740	65.86	80.68	1404	1.835	76.35	89.56	1717
1.750	66.58	81.56	1427	1.8385	81.08	99.31	1826
1.760	67.30	82.44	1451	1.840	80.59	98.72	1816
1.770	68.17	83.41	1478	1.840	78.01	95.60	1759

Note.—The highest percentages show lower specific gravities than those just below, the maximum being at 80.31 per cent. H₂SO₄. The impurities always present in commercial acid increase its density and consequently cause results deduced from sp. gr. to be unduly high.

CORRECTION FOR 1° C. (ADD WHEN ABOVE 15°, SUBTRACT WHEN BELOW 15° C.)

Sp. gr.	Correction.
1.170 (or less)	0.0005
1.170 1.150	0.0007
1.150 1.580	0.0008
1.580 1.750	0.0009
1.750 1.810	0.0010

SPECIFIC GRAVITIES OF SOLUTIONS OF AMMONIA AT 15° C. (Lunge and Wiernik).^a

Specific gravity.	NH ₃ per cent.	1 litre at 15° C. contains grams NH ₃ .	Correction of specific gravity for 1° C.
0.880	35.60	313.28	0.00066
0.885	33.67	297.98	0.00035
0.890	31.73	282.40	0.0001
0.895	30.03	268.77	0.000595
0.900	28.33	251.97	0.00057
0.905	26.01	211.09	0.000545
0.910	24.99	227.41	0.00052
0.915	23.35	213.65	0.000495
0.920	21.75	200.10	0.00047
0.925	20.18	186.67	0.000445
0.930	18.61	173.35	0.00042

^a From Lunge's *Technical Chemists' Handbook* (1916).

SPECIFIC GRAVITIES OF SOLUTIONS OF AMMONIA AT 15° C. *continued.*

Specific gravity.	NH ₃ percent	1 litre at 15° C. contains grams NH ₃	Correction of specific gravity for 1° C.
935	17.12	160.97	.00041
940	17.63	146.92	.00039
945	14.17	133.91	.000365
950	12.74	121.95	.00034
955	11.39	108.11	.000315
960	9.94	95.13	.00029
965	8.59	82.89	.000265
970	7.31	70.91	.00025
975	6.05	58.95	.00024
980	4.86	47.01	.00023
985	3.55	34.97	.00021
990	2.31	22.87	.00020
995	1.11	11.34	.00019

SPECIFIC GRAVITIES OF SOLUTIONS OF SODIUM AND POTASSIUM HYDROXIDES AT 15°/1° C.

Sp. gr.	% NaOH	% KOH	Sp. gr.	% NaOH	% KOH
1.010	0.86	1.18	1.280	25.03	29.00
1.020	1.69	2.28	1.290	25.96	29.96
1.030	2.60	3.36	1.300	26.85	30.91
1.040	3.50	4.41	1.310	27.85	31.81
1.050	4.31	5.33	1.320	28.83	32.78
1.060	5.20	6.60	1.330	29.80	33.70
1.070	6.13	7.68	1.340	30.71	34.63
1.080	7.05	8.76	1.350	31.75	35.55
1.090	7.95	9.82	1.360	32.79	36.46
1.100	8.78	10.87	1.370	33.73	37.37
1.110	9.67	11.92	1.380	34.71	38.28
1.120	10.56	12.96	1.390	35.68	39.18
1.130	11.55	14.01	1.400	36.67	40.09
1.140	12.49	15.04	1.410	37.66	40.98
1.150	13.34	16.08	1.420	38.67	41.87
1.160	14.19	17.10	1.430	39.67	42.76
1.170	15.06	18.13	1.440	40.68	43.63
1.180	16.00	19.15	1.450	41.70	44.50
1.190	16.91	20.17	1.460	42.75	45.37
1.200	17.81	21.17	1.470	43.80	46.23
1.210	18.71	22.16	1.480	44.85	47.09
1.220	19.65	23.17	1.490	45.89	47.93
1.230	20.60	24.14	1.500	46.94	48.78
1.240	21.47	25.13	1.510	48.00	49.64
1.240	22.33	26.10	1.520	49.05	50.48
1.260	23.23	27.07	1.530	50.10	51.32
1.270	24.13	28.04			

The above table is abbreviated from the very full tables given in Lang's *Technical Chemists' Handbook* (1916). The values given for KOH are calculated from the results obtained by Pickering (*J.C.S.*, 63, 860).

STRENGTH OF SATURATED SOLUTIONS OF A FEW
COMMON SALTS.*

	At 60° F.		
	Sigs. gr. of saturated solution.	Cc. of water dissolve 1 gram.	Grams in 1 liter of saturated solution
Acid, chromic	1.710	0.59	1075.5
„ citric	1.3326	0.54	861.7
„ tartaric	1.31	0.71	766.1
Alum, ammonia	1.0459	9.95	95.5
„ potash	1.046	9.70	97.7
Ammonium carbonate	1.094	3.94	221.5
„ chloride	1.077	2.8	47.4
Borax	1.0205	23.7	11.5
Calcium chloride (anhyd.)	1.1090	1.41	584.6
„ „ (CaCl ₂ ·2H ₂ O)	1.4096	0.82	724.2
Copper sulphate	1.193	2.79	314.8
Lead acetate	1.2554	2.37	372.5
Magnesium sulphate	1.2755	0.98	617.9
Mercuric chloride	1.0472	17.9	55.4
Potassium acetate	1.406	0.28	1099.2
„ bicarbonate	1.1688	3.21	277.7
„ dichromate	1.066	9.93	97.5
„ bromide	1.3615	1.59	525.7
„ chlorate	1.038	16.53	59.2
„ hydrate	1.553	0.647	942.9
„ iodide	1.7039	0.701	996.4
„ nitrate	1.1152	3.77	210.1
„ permanganate	1.6368	18.7	52.7
„ sulphate	1.0784	9.65	101.3
Sodium bicarbonate	1.0608	11.08	87.8
„ carbonate	1.1608	1.66	436.4
„ chloride	1.201	2.8	316.8
„ phosphate	1.0189	6.91	132.6
„ sulphate	1.3114	2.68	302.7
Zinc sulphate	1.452	0.65	880.0

Note.—In all the above determinations* the substances are calculated as of official (i.e., B.P.), not absolute, purity.

* H. G. Greenish in the *Pharm. Journal*, Dec. 26, 1903.

GLYCERIN TABLE.

Per cent Glycer in	Sp. gr. 15° C. = 59° F.	Sp. gr. 20° C. = 68° F.	Per cent Glycer in	Sp. gr. 15° C.	Per cent Glycer in	Sp. gr. 15° C.
100	1.26396	1.26348	74	1.19583	40	1.10253
99	1.26335	1.26085	73	1.19609	39	1.08908
98	1.26072	1.25822	72	1.19035	38	1.07564
97	1.25809	1.25560	71	1.18761	25	1.06236
96	1.25517	1.25297	70	1.18487	20	1.04930
95	1.25285	1.25034	69	1.18212	15	1.03552
94	1.25021	1.24771	68	1.17937	10	1.02169
93	1.24756	1.24508	67	1.17662	5	1.01189
92	1.24487	1.24246	66	1.17387		
91	1.24217	1.23983	65	1.17112		
90	1.23945	1.23720	64	1.16837		
89	1.23673	1.23449	63	1.16561		Sp. gr. 20° C.
88	1.23400	1.23178	62	1.16286		20
87	1.23128	1.22907	61	1.16011		
86	1.22855	1.22636	60	1.15737		
85	1.22583	1.22365	59	1.15462		
84	1.22310	1.22091	58	1.15187		
83	1.22038	1.21823	57	1.14912	70	1.18270
82	1.21766	1.21552	56	1.14637	60	1.15531
81	1.21493	1.21281	55	1.14362	50	1.12831
80	1.21221	1.21010	54	1.14088	40	1.10118
79	1.20949	1.20737	53	1.13811	30	1.07469
78	1.20677	1.20461	52	1.13539	20	1.04844
77	1.20404	1.20190	51	1.13265	10	1.02391
76	1.20131	1.19917	50	1.12990		
75	1.19857	1.19644	45	1.11618		

The above table is a combination of W. W. J. Nicol's excellent tables for the two temperatures above specified, as given in the *United States Dispensatory*, p. 653, and in *Watson's Dictionary of Chemistry* (most recent edition in each case). In the former work a complete table from 1-100% glycerin, at 15° C. is given.

The following formula is useful:—

$$\text{sp. gr. of dilute glycerine} = \frac{1.000}{.00265 + \frac{\% \text{ by weight of glycerine}}{100}}$$

The divisor .00265 is more accurate, however, for mixtures containing between 30 and 60% glycerin, and .0025 for those below 30%.

THE PREPARATION OF REAGENTS FOR WATER ANALYSIS.

Nessler's Solution.—First, dissolve 150 grams of stick potash in 150 c.c. of water, and set aside to cool. Next, dissolve 62.5 grams of potassium iodide in about 250 c.c. of water in a 1200 c.c. beaker, transfer about 10 c.c. to a small beaker, and add gradually to the main bulk, with constant stirring, a cold saturated solution of mercuric chloride (of which about 500 c.c. will be required) until a permanent precipitate is obtained. Now add the potassium iodide solution in the small beaker, which should redissolve the precipitate, and continue adding cautiously mercuric chloride until a slight precipitate remains undissolved on stirring. Add the cold potash solution, transfer the whole to a litre flask, make up to the mark with water, and pour it to a stoppered bottle. After standing about 12 hours the solution will have become clear, and should then be tested as follows: To 50 c.c. of ammonia-free water add 0.2 c.c. of standard ammonium chloride solution ($=0.00001$ gram NH_3), mix, and then add 2 c.c. of Nessler's solution, when a yellow tinge should appear *at once* if the latter solution be properly made. If the Nessler's solution is not sensitive—which will be the case if it is perfectly colourless, instead of the proper greenish-yellow tint—a little more mercuric chloride solution should be added, the whole well mixed, allowed to settle, and tested again.

Some Nessler's solutions give a red precipitate when added to water. The art of making a thoroughly satisfactory Nessler's solution can only be acquired by practice.

Alkaline permanganate solution.—Dissolve 200 grams of stick potash in water in a large porcelain dish and add a solution of 8 grams of potassium permanganate in water, using 1100 c.c. altogether. Boil rapidly until concentrated to about 900 c.c., add about 200 c.c. of hot distilled water, and continue boiling till the volume is reduced to a litre. When cool, pour at once into a bottle. Every fresh lot of solution made should be carefully tested before being used.

Standard solution of ammonium chloride.—Dissolve 1.5704 grams of pure dry ammonium chloride in a litre of ammonia-free water; of this take 100 c.c. and make up to a litre with water. Of this latter solution

1 c.c. = 0.00005 gram ammonia.

1.21 c.c. = 0.00005 gram nitrogen.

When 500 c.c. of water are distilled,

1 c.c. = 0.01 part NH_3 per 100,000.

1.21 c.c. = 0.01 part N „

The solution should be measured in a standard 1 c.c. pipette divided into hundredths.

Or, by dissolving 1.9094 gm. NH_4Cl in a litre of water, and diluting 100 c.c. of the solution to 1000 c.c., then of this latter solution

1 c.c. = 0.00005 gram ammoniacal nitrogen.

Standard silver nitrate solution. Dissolve 2.4 grams of recryst. silver nitrate in a litre of water and standardize against a solution of pure sodium chloride containing 0.8243 gram per litre (1 c.c. = 0.0005 gram chlorine).

1 c.c. silver nitrate solution = 0.0005 gram Cl,

or when 50 c.c. of water are titrated,

1 c.c. = 1 part combined chlorine per 100,000.

REAGENTS FOR DETERMINATION OF OXYGEN ABSORBED.

(i) *Dilute sulphuric acid.* Add 1 vol. of pure sulphuric acid to 3 vols. of water, and drop in potassium permanganate solution (ii) until the liquid retains a *very faint* pink tint after being kept at 80° F. for four hours.

(ii) *Standard solution of potassium permanganate.* Dissolve 0.395 gram of recryst. potassium permanganate in 1 litre of water.

1 c.c. = 0.0001 gram available oxygen.

(iii) *Potassium iodide solution.* Dissolve 1 part of the pure salt in 10 parts of water.

(iv) *Sodium thiosulphate solution.* Dissolve 1 gram of the crystals in 1 litre of water.

(v) *Starch indicator.* One part of clean potato starch, or arrow-root, is mixed smoothly into an emulsion with cold water, then poured gradually into about 150 or 200 times its weight of boiling water, the boiling continued for a few minutes, then allowed to stand and settle thoroughly. The clear solution only is to be used as the indicator, of which only a few drops are necessary.

Lintner's soluble starch acts well as an indicator, as it gives at once a clear solution in boiling water.

Thresh's starch solution (see p. 95) is also useful as an indicator.

REAGENTS REQUIRED FOR DETERMINATION OF HARDNESS.

Preparation of soap solution for Clark's test.—Weigh out 50 grams of commercial oleic acid in a beaker and add 100 c.c. of an alcoholic potash solution made by dissolving 20 grams of stick potash in 180 c.c. of industrial methylated spirit, and continue adding the same solution from a burette till a drop of the oleate test gives a red colour with phenol-phthalein spotted on a white tile—about 10 c.c. more being required. Measure the solution and make the volume to 400 c.c. by the addition of methylated spirit. 45 c.c. of the strong soap solution thus obtained are diluted with methylated spirit (2 vols.) and water (1 vol.) to a litre, allowed to stand for about 24 hours, filtered through a double Swedish filter, and standardized against standard calcium chloride

solution. The solution will be found to be a little too strong, and is diluted to exact strength, which is attained when 14.25 c.c. are required to form a permanent lather with 50 c.c. of the standard calcium chloride solution.

Standard calcium chloride solution.—Dissolve 0.2 gram of Iceland spar in dilute hydrochloric acid in a platinum dish, adding the acid gradually and having the dish covered with a large watch glass to prevent loss by spitting. When solution has taken place, rinse the glass into the dish, and evaporate to dryness on a water-bath; add water and again evaporate to dryness, and repeat this addition of water and evaporation two or three times in order to ensure complete expulsion of hydrochloric acid. Finally, take up the residue with distilled water, and make up the solution to 1 litre.

50 c.c. correspond to 0.01 gram CaCl_2 .

TABLES REQUIRED IN WATER ANALYSIS.

1. Tension of Aqueous Vapour in Millimetres of Mercury from 0° to 35° C.

° C.	mm.	° C.	mm.	° C.	mm.	° C.	mm.	° C.	mm.
0.0	4.600	2.5	5.491	5.0	6.534	7.5	7.751	10.0	9.165
1	.633	6	.530	1	.580	6	.804	1	.227
2	.667	7	.565	2	.625	7	.857	2	.288
3	.700	8	.608	3	.671	8	.910	3	.350
4	.733	9	.647	4	.717	9	.964	4	.412
0.5	.767	3.0	5.687	5.5	.763	8.0	8.017	10.5	.474
6	.801	1	.727	6	.810	1	.072	6	.537
7	.836	2	.767	7	.857	2	.126	7	.601
8	.871	3	.807	8	.904	3	.181	8	.665
9	.905	4	.848	9	.951	4	.236	9	.728
1.0	4.940	3.5	.890	6.0	6.998	8.5	.291	11.0	9.792
1	.975	6	.930	1	7.047	6	.347	1	.857
2	5.011	7	.972	2	.095	7	.404	2	.923
3	.047	8	6.014	3	.144	8	.461	3	.989
4	.082	9	.056	4	.193	9	.517	4	10.054
1.5	.118	4.0	6.097	6.5	.242	9.0	8.574	11.5	.120
6	.155	1	.140	6	.292	1	.632	6	.187
7	.191	2	.183	7	.342	2	.690	7	.255
8	.228	3	.220	8	.392	3	.748	8	.322
9	.265	4	.270	9	.442	4	.807	9	.389
2.0	5.302	4.5	.313	7.0	7.492	9.5	.865	12.0	10.457
1	.340	6	.357	1	.544	6	.925	1	.526
2	.378	7	.401	2	.595	7	.985	2	.596
3	.416	8	.415	3	.647	8	9.045	3	.665
4	.454	9	.490	4	.699	9	.105	4	.734

TABLES REQUIRED IN WATER ANALYSIS. TABLE I. *continued.*

°C.	mm.	°C.	mm.	°C.	mm.	°C.	mm.	°C.	mm.
12.5	10.804	17.1	14.513	21.7	19.595	26.3	25.458	30.9	33.215
6	875	2	605	8	427	4	588	31.0	33.405
7	947	3	697	9	511	5	738	1	596
8	11.019	4	790	22.0	19.653	6	891	2	787
9	999	17.5	882	1	580	7	26.045	3	980
13.0	11.162	6	977	2	661	8	198	1	31.174
1	235	7	15.072	3	10.022	9	351	2.5	368
2	309	8	107	4	943	27.0	26.505	6	561
3	383	9	202	22.5	265	1	663	7	761
4	456	18.0	15.357	6	389	2	826	8	959
13.5	530	1	454	7	511	3	978	9	35.159
6	605	2	552	8	663	4	27.156	32.0	35.859
7	681	3	650	9	763	27.5	291	1	559
8	757	4	747	23.0	20.888	6	155	2	760
9	832	18.5	845	1	21.016	7	617	3	962
14.0	11.908	6	945	2	144	8	778	4	36.165
1	986	7	16.045	3	272	9	939	32.5	37.0
2	12.064	8	115	4	400	28.0	28.101	6	576
3	142	9	246	23.5	528	1	267	7	783
4	220	19.0	16.340	6	21.559	2	193	8	977
14.5	298	1	449	7	790	3	599	9	37.2
6	378	2	552	8	921	4	765	32.0	37.410
7	458	3	655	9	23.053	5	931	1	621
8	538	4	758	24.0	22.184	6	29.101	2	832
9	619	19.5	861	1	319	7	271	3	3.045
15.0	12.699	6	967	2	453	8	111	4	258
1	781	7	17.073	3	588	9	612	33.5	473
2	864	8	179	4	723	29.0	29.782	6	689
3	947	9	285	24.5	858	1	956	7	906
4	13.029	26.0	17.391	6	996	2	30.131	8	39.124
15.5	112	1	500	7	23.135	3	305	9	311
6	197	2	608	8	273	4	179	34.0	39.565
7	281	3	717	9	411	29.5	654	1	786
8	366	4	826	25.0	23.550	6	823	2	10.007
9	451	20.5	935	1	692	7	31.011	3	230
16.0	13.536	6	18.047	2	834	8	190	4	455
1	623	7	159	3	976	9	369	34.5	680
2	710	8	271	4	24.119	30.0	31.548	5	907
3	797	9	383	25.5	261	1	729	7	41.135
4	885	21.0	18.195	6	406	2	911	8	364
16.5	972	1	610	7	552	3	32.094	9	595
6	1062	2	721	8	697	4	278	35.0	827
7	1151	3	839	9	842	30.5	463		
8	241	4	954	26.0	21.988	6	650		
9	331	21.5	19.069	1	25.138	7	837		
17.0	14.421	6	187	2	288	8	33.026		

TABLES REQUIRED IN WATER ANALYSIS- continued.

II. Reduction of Cubic Centimetres of Nitrogen to Grams.

Log. 0.0012507 for each tenth of a degree from 0° to 30° C.
 (1 + 0.03665 t) 760

t	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	6.21634	618	602	586	570	554	539	523	507	491
1	475	459	443	427	411	395	379	363	347	332
2	317	301	285	269	253	237	221	205	189	174
3	159	143	127	111	95	80	65	49	33	18
4	002	986	970	955	939	923	908	892	876	861
5	6.20845	829	813	798	782	766	751	735	719	704
6	6.20689	673	658	642	627	611	596	580	565	549
7	534	518	503	487	472	456	441	425	410	394
8	479	464	448	433	417	402	386	371	355	340
9	225	210	194	179	163	148	132	117	101	86
10	071	056	040	025	009	994	979	963	948	932
11	6.19917	902	887	872	856	841	826	811	796	780
12	6.19765	750	735	720	704	689	674	659	644	628
13	613	598	583	568	552	537	522	507	492	476
14	461	446	431	416	401	386	371	356	341	325
15	310	295	280	265	250	235	220	205	190	174
16	159	144	129	114	99	84	69	54	39	24
17	009	991	979	964	949	934	919	904	889	874
18	6.18859	844	829	814	799	784	769	754	739	724
19	710	695	680	665	650	635	620	606	591	576
20	562	547	532	517	502	487	472	458	443	428
21	414	399	384	369	354	339	324	310	295	280
22	266	251	236	221	206	191	176	162	147	132
23	119	104	89	75	60	45	31	16	02	987
24	6.17973	958	943	929	914	899	885	870	856	841
25	827	812	797	783	768	753	739	724	710	695
26	681	666	651	637	622	607	593	578	564	549
27	536	521	507	492	478	463	449	434	420	405
28	391	376	362	347	333	318	304	289	275	260
29	247	232	218	203	189	175	160	146	131	117

TABLES REQUIRED IN WATER ANALYSIS continued.

III. Loss of Nitrogen by Evaporation of NH_3 with Sulphurous Acid.

Parts per 100,000.

NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N
6.0	1.727	4.8	1.431	3.6	.977	2.4	.502	1.2	.250
5.9	1.707	4.7	1.411	3.5	.957	2.3	.483	1.1	.248
5.8	1.688	4.6	1.392	3.4	.938	2.2	.463	1.0	.226
5.7	1.668	4.5	1.372	3.3	.918	2.1	.443	0.9	.196
5.6	1.648	4.4	1.353	3.2	.899	2.0	.423	.8	.166
5.5	1.628	4.3	1.333	3.1	.879	1.9	.403	.7	.136
5.4	1.609	4.2	1.314	3.0	.859	1.8	.382	.6	.106
5.3	1.589	4.1	1.294	2.9	.839	1.7	.360	.5	.077
5.2	1.569	4.0	1.275	2.8	.819	1.6	.339	.4	.048
5.1	1.549	3.9	1.255	2.7	.799	1.5	.318	.3	.017
5.0	1.530	3.8	1.236	2.6	.779	1.4	.297	.2	.032
4.9	1.490	3.7	1.216	2.5	.759	1.3	.262	.1	.017

IV. Loss of Nitrogen by Evaporation of NH_3 with Hydric Metaphosphate.

Parts per 100,000.

Volume evaporated.	NH_3	Loss of N	Volume evaporated.	NH_3	Loss of N	Volume evaporated.	NH_3	Loss of N
100 c.c.	10.0	.483	100 c.c.	8.3	.424	100 c.c.	6.6	.365
"	9.9	.480	"	8.2	.421	"	6.5	.361
"	9.8	.476	"	8.1	.417	"	6.4	.358
"	9.7	.473	"	8.0	.414	"	6.3	.354
"	9.6	.469	"	7.9	.410	"	6.2	.351
"	9.5	.466	"	7.8	.407	"	6.1	.348
"	9.4	.462	"	7.7	.403	"	6.0	.345
"	9.3	.459	"	7.6	.400	"	5.9	.341
"	9.2	.455	"	7.5	.396	"	5.8	.337
"	9.1	.452	"	7.4	.393	"	5.7	.333
"	9.0	.448	"	7.3	.389	"	5.6	.330
"	8.9	.445	"	7.2	.386	"	5.5	.326
"	8.8	.441	"	7.1	.382	"	5.4	.322
"	8.7	.438	"	7.0	.379	"	5.3	.318
"	8.6	.434	"	6.9	.375	"	5.2	.314
"	8.5	.431	"	6.8	.372	"	5.1	.310
"	8.4	.428	"	6.7	.368	"	5.0	.306

TABLES REQUIRED IN WATER ANALYSIS—continued.
 VI. Loss of Nitrogen by Evaporation of NH_3 with Hydric
 Metaphosphate.
 Parts per 100,000

Volume evaporated.	N as NH_3	Loss of N	Volume evaporated.	N as NH_3	Loss of N	Volume evaporated.	N as NH_3	Loss of N
100 c.c.	8.2	482	100 c.c.	5.1	352	100 c.c.	2.1	192
"	8.1	477	"	5.0	347	"	2.0	186
"	8.0	473	"	4.9	343	"	1.9	180
"	7.9	469	"	4.8	338	"	1.8	173
"	7.8	465	"	4.7	334	"	1.7	167
"	7.7	461	"	4.6	329	"	1.6	161
"	7.6	456	"	4.5	324	"	1.5	154
"	7.5	452	"	4.4	319	"	1.4	148
"	7.4	448	"	4.3	315	"	1.3	142
"	7.3	444	"	4.2	310	"	1.2	136
"	7.2	440	"	4.1	305	"	1.1	129
"	7.1	435	"	4.0	301	"	1.0	123
"	7.0	431	"	3.9	296	"	.9	117
"	6.9	427	"	3.8	291	"	.8	111
"	6.8	423	"	3.7	286	250 c.c.	.7	108
"	6.7	419	"	3.6	281	"	.6	103
"	6.6	414	"	3.5	277	"	.5	101
"	6.5	410	"	3.4	272	500 c.c.	.4	98
"	6.4	406	"	3.3	267	"	.3	93
"	6.3	402	"	3.2	261	1000 c.c.	.2	92
"	6.2	398	"	3.1	255	"	.1	91
"	6.1	394	"	3.0	249	"	.09	91
"	6.0	389	"	2.9	242	"	.08	91
"	5.9	385	"	2.8	236	"	.07	90
"	5.8	381	"	2.7	230	"	.06	90
"	5.7	377	"	2.6	223	"	.05	90
"	5.6	373	"	2.5	217	"	.04	90
"	5.5	368	"	2.4	211	"	.03	90
"	5.4	364	"	2.3	205	"	.02	90
"	5.3	360	"	2.2	198	"	.01	90
"	5.2	356						

VII. Table of Hardness.
 (50 c.c. of water per gal.)

Volume of Soap solution.	CaCO_3 per 100,000	Degrees of Hard- ness.*	Volume of Soap solution.	CaCO_3 per 100,000	Degrees of Hard- ness.	Volume of Soap solution.	CaCO_3 per 100,000	Degrees of Hard- ness.
c.c.			c.c.			c.c.		
0.7	0.00	0.00	1.3	0.95	0.67	1.9	1.82	1.27
0.8	0.16	0.11	4	1.11	0.78	2.0	1.95	1.37
0.9	0.32	0.22	5	1.27	0.89	3	2.08	1.46
1.0	0.48	0.34	6	1.43	1.00	2	2.21	1.55
1	0.63	0.44	7	1.56	1.09	3	2.34	1.64
2	0.79	0.55	8	1.69	1.18	4	2.47	1.73

* Each degree of hardness indicates one grain of CaCO_3 per gallon.

TABLES REQUIRED IN WATER ANALYSIS. TABLE VII.—*continued.*

Volume of Soap solution.	CaCO ₃ per 100,000	Degrees of Hardness.	Volume of Soap solution.	CaCO ₃ per 100,000	Degrees of Hardness.	Volume of Soap solution.	CaCO ₃ per 100,000	Degrees of Hardness.
c.			c.c.			c.c.		
2.5	2.60	1.82	7.1	9.00	6.30	11.7	15.95	11.17
3	2.73	1.91	7.2	9.14	6.40	11.8	16.11	11.28
4	2.86	2.00	7.3	9.29	6.50	11.9	16.27	11.39
5	2.99	2.09	7.4	9.43	6.60	12.0	16.43	11.50
6	3.12	2.18	7.5	9.57	6.70	12.1	16.59	11.61
7	3.25	2.28	7.6	9.71	6.80	12.2	16.75	11.73
8	3.38	2.37	7.7	9.86	6.90	12.3	16.90	11.83
9	3.51	2.46	7.8	10.00	7.00	12.4	17.06	11.94
10	3.64	2.55	7.9	10.15	7.11	12.5	17.22	12.05
11	3.77	2.64	8.0	10.30	7.21	12.6	17.38	12.17
12	3.90	2.73	8.1	10.45	7.32	12.7	17.54	12.28
13	4.03	2.82	8.2	10.60	7.42	12.8	17.70	12.39
14	4.16	2.91	8.3	10.75	7.53	12.9	17.86	12.50
15	4.29	3.00	8.4	10.90	7.63	13.0	18.02	12.61
16	4.43	3.10	8.5	11.05	7.74	13.1	18.17	12.72
17	4.57	3.20	8.6	11.20	7.84	13.2	18.33	12.83
18	4.71	3.30	8.7	11.35	7.95	13.3	18.49	12.94
19	4.86	3.40	8.8	11.50	8.05	13.4	18.65	13.06
20	5.00	3.50	8.9	11.65	8.16	13.5	18.81	13.17
21	5.14	3.60	9.0	11.80	8.26	13.6	18.97	13.28
22	5.29	3.70	9.1	11.95	8.37	13.7	19.13	13.39
23	5.43	3.80	9.2	12.11	8.48	13.8	19.29	13.50
24	5.57	3.90	9.3	12.26	8.58	13.9	19.44	13.61
25	5.71	4.00	9.4	12.41	8.69	14.0	19.60	13.72
26	5.86	4.10	9.5	12.56	8.79	14.1	19.76	13.83
27	6.00	4.20	9.6	12.71	8.90	14.2	19.92	13.94
28	6.14	4.30	9.7	12.85	9.00	14.3	20.08	14.06
29	6.29	4.40	9.8	13.01	9.11	14.4	20.24	14.17
30	6.43	4.50	9.9	13.16	9.21	14.5	20.40	14.28
31	6.57	4.60	10.0	13.31	9.32	14.6	20.56	14.39
32	6.71	4.70	10.1	13.46	9.42	14.7	20.71	14.50
33	6.86	4.80	10.2	13.62	9.53	14.8	20.87	14.61
34	7.00	4.90	10.3	13.76	9.63	14.9	21.03	14.72
35	7.14	5.00	10.4	13.91	9.74	15.0	21.19	14.83
36	7.29	5.10	10.5	14.06	9.84	15.1	21.35	14.95
37	7.43	5.20	10.6	14.21	9.95	15.2	21.51	15.06
38	7.57	5.30	10.7	14.37	10.06	15.3	21.68	15.18
39	7.71	5.40	10.8	14.52	10.16	15.4	21.85	15.30
40	7.86	5.50	10.9	14.68	10.28	15.5	22.02	15.41
41	8.00	5.60	11.0	14.84	10.39	15.6	22.18	15.53
42	8.14	5.70	11.1	15.00	10.50	15.7	22.35	15.65
43	8.29	5.80	11.2	15.16	10.61	15.8	22.52	15.76
44	8.43	5.90	11.3	15.32	10.72	15.9	22.69	15.88
45	8.57	6.00	11.4	15.48	10.84	16.0	22.86	16.00
46	8.71	6.10	11.5	15.63	10.94			
47	8.86	6.20	11.6	15.79	11.05			

* Each degree of hardness indicates one grain of CaCO₃ per gallon.

TABLES REQUIRED IN WATER ANALYSIS—continued

VIII. Clark's Table of Hardness of Water.

Degrees of Hardness.	Measures of Soap solution.	Differences for the next 1° of Hardness.	Degrees of Hardness.	Measures of Soap solution.	Differences for the next 1° of Hardness.
0 (distilled water)			8	17.5	1.9
1	1.1	1.8	9	19.4	1.9
2	3.2	2.2	10	21.3	1.8
3	5.4	2.2	11	23.1	1.8
4	7.6	2.0	12	24.9	1.8
5	9.6	2.0	13	26.7	1.8
6	11.6	2.0	14	28.5	1.8
7	13.6	2.0	15	30.3	1.7
		1.9	16	32.0	..

Each measure equals 10 grains the quantity of water operated upon equal 1000 grains, and each "degree of hardness" indicates 1 grain of anhydrous carbonate per gallon.

THE DETERMINATION OF NITRATES IN WATER BY
PHENOL DISULPHONIC ACID

(Sprengel's method modified)

Solutions required.

(1) *Phenol disulphonic Acid.* Mix together 2 parts by measure of phenol,* liquefied by heat, and 5 parts of pure concentrated sulphuric acid, and heat in a porcelain basin on the water bath for about 8 hours, with occasional stirring. When cool, add 1½ volumes of water and ½ volume strong hydrochloric acid to each volume of the phenol-disulphonic acid.

Convenient quantities are 80 c.c. phenol, 200 c.c. H_2SO_4 , 420 c.c. water and 140 c.c. HCl , producing 840 c.c. of a light brown solution, which is ready for immediate use.

(2) *Standard Potassium Nitrate.* 0.0722 gram KNO_3 crystals are dissolved in a litre of water.†

10 c.c. = 0.0001 gram N, or 1 part of N in 100,000 of water when 10 c.c. are evaporated.

(3) 10% ammonia (1 vol. 880 + 2 vols. water); or potash solution, made by dissolving 330 grains stick potash in one litre of water.

About 15 c.c. of either of the above to be used for each residue.

* The determination is made as follows: 10 c.c. of the water under examination and 10 c.c. standard KNO_3 are pipetted into 15 c.c. beakers and evaporated nearly to dryness on a hot iron plate, the

* Calvert's No. 1 medical carbolic acid answers well.

† Or dissolve 0.7217 gram KNO_3 in a litre of distilled water. 1 c.c. of this may be used for a standard, but it is better to dilute 50 c.c. to 500 c.c. and measure out 10 c.c. of the latter for each set of determinations.

operation being completed on the top of the water-oven. To each residue 1 c.c. of the phenol-disulphonic acid solution is added, and the latter brought into contact with the whole of the residue in each beaker. This is done simply by rotating the beaker, held in an inclined position, until the entire residue has been moistened; no stirring rod is required. The beakers are then left on the top of the water-oven for 15 minutes and at the end of that time are at once filled up with cold water and removed to the working-bench, if a number of residues are being treated simultaneously. The standard solution is then rinsed into a 100 c.c. graduated cylinder, a slight excess (about 1.5 c.c.) of 10% ammonia or of caustic potash solution added, the 100 c.c. made up by the addition of water, and the yellow liquid transferred to a Nessler glass (6 x 1½ ins.). Each of the other beakers is then successively treated in the same way and comparison made with the standard as in Nesslerizing. The colours are best compared when the Nessler glasses are held side by side at a short distance above a thick white filter paper.

The results obtained with the aid of Table IX. are only approximate when more than about 1.5 parts of nitric nitrogen per 100,000 of water are present. In all cases where the nitric nitrogen exceeds 1.5 parts per 100,000, it is necessary to make a second determination, using such a volume of water as to give a colour very nearly equal to that of the standard.* Thus, if a water showed 2 parts of nitric nitrogen per 100,000, 5 c.c. should be evaporated to dryness and treated as before; one giving 4 parts would really contain decidedly more, and 20 c.c. of the sample should be transferred to a 100 c.c. measuring flask, diluted to the mark with water, and 10 c.c. of the thoroughly mixed solution (= 2 c.c. original water) evaporated down for a fresh determination. In the case of very good waters, the solution and washings should be kept as small as possible, since a portion of the standard 100 c.c. will have to be poured into the cylinder in order to match the colours. Suppose that 0.25 part of nitric nitrogen is thus shown, then 40 c.c. of the water are measured into a larger beaker, evaporated to a small bulk, rinsed into a small beaker and evaporated to dryness, etc., as above; or 20 c.c. of the water may be taken and compared with a standard made by using only 5 c.c. of the KNO_3 solution. (This method is inapplicable in the presence of thiocyanates†).

Chanot, Pratt and Redfield‡ have recently made a study of this method, and their results may briefly be summarized as follows:—

A modified phenol-sulphonic acid method. Preparation of reagents required.

Phenol-disulphonic acid.—Dissolve 25 gm. of pure white phenol in 150 c.c. of pure concentrated sulphuric acid, add 75 c.c. of fuming sulphuric acid (13% SO_3), stir well, and heat for 2 hours at about 100° C.

* If the second experiment is to be made the same day, the same standard, if covered with a beaker, can be used again.

† See H. Silvester, *Journ. Soc. Chem. Ind.*, 1912, 31, 95.

‡ *The Chemical News*, 1911, 104, p. 146, et seq.

Standard silver sulphate.—4.3303 gm. of silver sulphate (free from nitrate) to the litre.

1 c.c. = 1 c.c. of standard AgNO_3 (1.6186 gm. per litre)
equivalent to 0.001 gram chlorine.

Method of procedure. First determine the alkalinity, the chlorine and nitrite content, and the colour of the sample. Should the colour be high, decolorize with "aluminium cream."

Measure out such a volume of the water (100 c.c. or less) as will contain about 1 part of nitric nitrogen per 100,000, fairly low colorimeter readings having been found most reliable. Add sufficient N/25 or N/50 sulphuric acid barely to neutralize the alkalinity, then enough standard silver sulphate solution to precipitate all but 0.5 mgm. of the chlorine. Heat to boiling, add a little aluminium cream, filter, and wash with small amounts of hot water. Evaporate the filtrate to dryness, add 2 c.c. of the disulphonic acid reagent, rubbing with a glass rod to ensure intimate contact. Should the residue be compact or vitreous in appearance from the presence of much magnesium or iron, place the evaporator on the water bath for a few minutes. Dilute with water and add slowly KOH solution (1:12 normal) until the maximum colour is developed. Transfer to a colorimeter cylinder, filtering if necessary, and compare with a potassium nitrate or tripotassium nitrophenol disulphonate standard.

Should nitrites be present in excess of 0.1 part of nitrous nitrogen per 100,000, a slight error will be introduced. They should, therefore, be removed by heating the sample a few moments with a few drops of hydrogen peroxide (free from nitrates) repeatedly added, or dilute potassium permanganate may be added in the cold until a trace of pink appears and a correction applied to the final nitrate nitrogen reading due to the conversion of the nitrites to nitrates.

Directions for making permanent standards are given.

TABLES REQUIRED IN WATER ANALYSIS—continued.

IX. Estimation of Nitrogen as Nitrates by Sprengel's Method (for waters containing more than one part of N in 100,000).

No. of c.c. of yellow solution equal to the standard 100 c.c.	Nitrogen as Nitrates.		No. of c.c. of yellow solution equal to the standard 100 c.c.	Nitrogen as Nitrates.	
	Parts per 100,000.	Grains per gallon.		Parts per 100,000.	Grains per gallon.
100	1.00	0.70	50	2.00	1.40
95	1.05	0.74	48	2.08	1.46
90	1.11	0.78	46	2.17	1.52
85	1.18	0.83	45	2.22	1.55
80	1.25	0.88	44	2.27	1.59
78	1.28	0.90	42	2.34	1.67
76	1.32	0.92	40	2.50	1.75
75	1.33	0.93	38	2.63	1.84
74	1.35	0.95	36	2.78	1.95
72	1.39	0.97	35	2.86	2.00
70	1.43	1.00	34	2.94	2.06
68	1.47	1.03	32	3.16	2.19
66	1.51	1.06	30	3.33	2.33
65	1.54	1.08	28	3.57	2.50
64	1.55	1.09	26	3.85	2.70
62	1.61	1.13	25	4.00	2.80
60	1.67	1.17	24	4.17	2.92
58	1.72	1.20	22	4.55	3.19
56	1.78	1.25	20	5.00	3.50
55	1.82	1.27	18	5.55	3.89
54	1.85	1.30	16	6.25	4.38
52	1.92	1.34	15	6.67	4.67

X. Table for the Conversion of Parts per 100,000 into Grains per Gallon.

Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
1	0.7	9	6.3	17	11.9	25	17.5
2	1.4	10	7.0	18	12.6	26	18.2
3	2.1	11	7.7	19	13.3	27	18.9
4	2.8	12	8.4	20	14.0	28	19.6
5	3.5	13	9.1	21	14.7	29	20.3
6	4.2	14	9.8	22	15.4	30	21.0
7	4.9	15	10.5	23	16.1	31	21.7
8	5.6	16	11.2	24	16.8	32	22.4

TABLES REQUIRED IN WATER ANALYSIS. TABLE X. *continued.*

Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
33	23.1	78	54.6	123	86.1	168	117.6
34	23.8	79	55.3	124	86.8	169	118.3
35	24.5	80	56.0	125	87.5	170	119.0
36	25.2	81	56.7	126	88.2	171	119.7
37	25.9	82	57.4	127	88.9	172	120.4
38	26.6	83	58.1	128	89.6	173	121.1
39	27.3	84	58.8	129	90.3	174	121.8
40	28.0	85	59.5	130	91.0	175	122.5
41	28.7	86	60.2	131	91.7	176	123.2
42	29.4	87	60.9	132	92.4	177	123.9
43	30.1	88	61.6	133	93.1	178	124.6
44	30.8	89	62.3	134	93.8	179	125.3
45	31.5	90	63.0	135	94.5	180	126.0
46	32.2	91	63.7	136	95.2	181	126.7
47	32.9	92	64.4	137	95.9	182	127.4
48	33.6	93	65.1	138	96.6	183	128.1
49	34.3	94	65.8	139	97.3	184	128.8
50	35.0	95	66.5	140	98.0	185	129.5
51	35.7	96	67.2	141	98.7	186	130.2
52	36.4	97	67.9	142	99.4	187	130.9
53	37.1	98	68.6	143	100.1	188	131.6
54	37.8	99	69.3	144	100.8	189	132.3
55	38.5	100	70.0	145	101.5	190	133.0
56	39.2	101	70.7	146	102.2	191	133.7
57	39.9	102	71.4	147	102.9	192	134.4
58	40.6	103	72.1	148	103.6	193	135.1
59	41.3	104	72.8	149	104.3	194	135.8
60	42.0	105	73.5	150	105.0	195	136.5
61	42.7	106	74.2	151	105.7	196	137.2
62	43.4	107	74.9	152	106.4	197	137.9
63	44.1	108	75.6	153	107.1	198	138.6
64	44.8	109	76.3	154	107.8	199	139.3
65	45.5	110	77.0	155	108.5	200	140.0
66	46.2	111	77.7	156	109.2	201	140.7
67	46.9	112	78.4	157	109.9	202	141.4
68	47.6	113	79.1	158	110.6	203	142.1
69	48.3	114	79.8	159	111.3	204	142.8
70	49.0	115	80.5	160	112.0	205	143.5
71	49.7	116	81.2	161	112.7	206	144.2
72	50.4	117	81.9	162	113.4	207	144.9
73	51.1	118	82.6	163	114.1	208	145.6
74	51.8	119	83.3	164	114.8	209	146.3
75	52.5	120	84.0	165	115.5	210	147.0
76	53.2	121	84.7	166	116.2	211	147.7
77	53.9	122	85.4	167	116.9	212	148.4

TABLES REQUIRED IN WATER ANALYSIS. TABLE X.—*continued*.

Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
213	149.1	223	156.1	233	163.1	243	170.1
214	149.8	224	156.8	234	163.8	244	170.8
215	150.5	225	157.5	235	164.5	245	171.5
216	151.2	226	158.2	236	165.2	246	172.2
217	151.9	227	158.9	237	165.9	247	172.9
218	152.6	228	159.6	238	166.6	248	173.6
219	153.3	229	160.3	239	167.3	249	174.3
220	154.0	230	161.0	240	168.0	250	175.0
221	154.7	231	161.7	241	168.7		
222	155.4	232	162.4	242	169.4		

CALCULATION OF THE RESULTS OF WATER ANALYSIS.

Substance estimated.	Quantity of Water taken.	To get Grams per gallon.	Logarithms.
$\text{Na}_2\text{Si}_2\text{O}_5$ (Crum).	250 c.c.	c.c. of NO at N.T.P. $\times \frac{17.0}{17.0}$	1.243 561
NH_3 (copper zinc).	100 c.c.	grams of NH_3 $\times \frac{57.43}{17.0}$	2.760 290
" (aluminium).	50 c.c.	" $\times \frac{11.046}{17.0}$	3.061 250
O absorbed.	250 c.c. + 10 c.c. $\text{K}_2\text{Mn}_2\text{O}_8$	$0.28 \left(\frac{N}{N} - W \right)^\dagger$	
"	250 c.c. + 15 c.c. $\text{K}_2\text{Mn}_2\text{O}_8$	$0.28 \left(\frac{N}{N} - W \right)^\dagger$	
Total solids.	250 c.c.	grams $\times 280$	2.447 1580

* Or thus. Let v = vol. of NO obtained from 250 c.c. of the water

b = height of Bar.

w = tension of aqueous vapour at the observed temperature (see Table I.).

Then N in grains per gallon = $v \times \frac{0.012507}{760(1 + 0.00367 t)} \times (b - w) \times 140$

For logs. of $\frac{0.012507}{760(1 + 0.00367 t)}$ for different values of t see Table II

Log. 140 = 2.146 1280.

† 8 c.c. of $\text{Na}_2\text{S}_2\text{O}_3$ corresponding to 10 c.c. $\text{K}_2\text{Mn}_2\text{O}_8$.

W = " " required by the water under examination.

THRESH'S SOLUTION OF STARCH AND DETECTION OF NITRATES.

Thresh states that, having tried numerous formulae for starch solutions, he finds that the only one that can be relied on is the following:—

Starch	4 cups.
Zinc chloride	20 "
Water	1 gal.

Dissolve the zinc chloride in about 150 c.c. of water, and filter. Mix the starch with a few c.c. of cold water into a thin paste, and pour into the boiling solution of zinc chloride with constant stirring. Dilute to a litre. Allow the flocculent matter to settle, and filter the supernatant fluid through a small jelly-bag.

Detection of Nitrates.—To 50 c.c. of the water (previously aerated by well shaking) add 1 c.c. each of dilute HCl (1 in 6), potassium iodide solution (10 per cent.), and the above starch solution and stir. If no blue colour develops in two minutes, nitrates may be considered to be absent. With 0.1 part of nitrous nitrogen in 100,000 a dark blue colour is produced instantly, with 0.03 part per 100,000 the colour appears in a few seconds, and with 0.01 per 100,000 in about thirty seconds.*

EXAMPLE OF THE DETERMINATION OF NITRATES BY GRIMM'S METHOD.

0.5 gram of a substance containing nitrate of soda treated by Grimm's method gave 13.6 c.c. of NO measured at 8° C. and 737 mm. Bar. To find the percentages of nitrogen and of sodium nitrate present.

Bar. 737 mm.

Tension of aqueous vapour at 8° C. 8 mm. by Table I.

Pressure on the dry gas 729 mm.

NO contains half its volume of nitrogen.

$$\text{Weight of nitrogen} = \frac{r}{2} \left(\frac{h}{h-r} \right) \times \frac{0.012507}{760 (1 + 0.00367 t)}$$

$$= \frac{6.8 \times 729}{2} \times \frac{0.012507}{760 (1 + 0.00367 \times 8)}$$

$$\log 6.8 = 0.83251$$

$$\log 729 = 2.86273$$

$$\log \text{ fraction by Table II.} = 6.20379$$

$$3.89903$$

0.007926 gram

Nitrogen in 0.5 gram

$$0.007926 \times 200 = 1.59 \text{ nitrogen}$$

and by logs 1.59 nitrogen = 9.65% sodium nitrate.

* From Dr Thresh's *The Examination of Water and Water Supplies*, Second edition, 1913, p. 292.

WATER AND SEWAGE EXAMINATION RESULTS.

(British Association Report, 1899.)

The Committee appointed by the British Association to devise a uniform system of recording the results of the chemical and bacteriological examination of water and sewage reported as follows:—

It is desirable that results of analysis should be expressed in parts per 100,000, except in the case of dissolved gases, when these should be stated as c.c. of gas at 0° C. and 760 mm. in 1 litre of water. This method of recording results is in accordance with that suggested by the Committee appointed in 1887 to confer with the Committee of the American Association for the advancement of science, with a view to forming a uniform system of recording the results of water analysis.

It is suggested that in the case of all nitrogen compounds the results be expressed as parts of nitrogen per 100,000, including the ammonia expelled on boiling with alkaline permanganate, which should be termed *albuminoid nitrogen*. The nitrogen will therefore be returned as:

- (1) Ammoniacal nitrogen from free and saline ammonia.
- (2) Nitrous nitrogen from nitrites.
- (3) Nitric nitrogen from nitrates.
- (4) Organic nitrogen (either by Kjeldahl or by combustion, but the process used should be stated).
- (5) Albuminoid nitrogen.

The total nitrogen of all kinds will be the sum of the first four determinations.

The Committee are of opinion that the percentage of nitrogen oxidized—that is, the ratio of (2) and (3) to (1) and (1) gives sometimes a useful measure of the stage of purification of a particular sample. The purification effected by a process will be measured by the amount of oxidized nitrogen as compared with the total amount of nitrogen existing in the crude sewage.

In raw sewage and in effluents containing suspended matter, it is also desirable to determine how much of the organic nitrogen is present in the suspended matter.

In sampling, the Committee suggest that the bottles should be filled nearly completely with the liquid, only a small air-bubble being allowed to remain in the neck of the bottle. The time at which a sample is drawn, as well as the time at which its analysis is begun, should be noted. An effluent should be drawn to correspond as nearly as possible with the original sewage, and both it and the sewage should be taken in quantities proportional to the rate of flow when that varies (e.g. in the emptying of a filter-bed).

In order to avoid the multiplication of analyses, the attendant at a sewage works (or any other person who draws the samples) might be provided with sets of twelve or twenty-four stoppered

quarter-Winchester bottles, one of which should be filled every hour or every two hours, and on the label of each bottle the rate of flow at the time should be written. When the bottles reach the laboratory, quantities would be taken from each proportional to these rates of flow and mixed together, by which means a fair average sample for the twenty-four hours would be obtained.

The Committee were unable to suggest a method of reporting bacterial results, including incubator tests, that would be likely to be acceptable to all workers.

The Committee consisted of Professor W. Ramsay (chairman), Sir W. Crookes, Professors F. Gowen, F. E. Frankland, and R. Boyce, and Dr Rideal (secretary).

STANDARDS FOR SEWAGE EFFLUENTS.

In 1898 a Royal Commission was appointed to inquire and report what methods of treating and disposing of sewage (including any liquid from any factory or manufacturing process) may properly be adopted. Between 1902 and 1913 eight Reports were issued and the Final Report* in 1915. The principal conclusions finally arrived at were briefly as follows:

The nuisance-producing power of a liquid sewage or effluent is proportional to its power of deoxygenating the water of the stream into which it is discharged.

The dissolved oxygen absorption test provides the most trustworthy chemical index of the actual state of a stream and should be adopted for purposes of a standard.

A river of average purity shows an absorption of 0.2 part per 100,000 of dissolved oxygen in 5 days at the temperature of 65° F.

For administrative reasons a fixed general standard should be applied to the effluent alone, and should be relaxed or made more stringent as local circumstances permitted or required. This general or normal standard for effluents is thus defined:

An effluent in order to comply with the general standard must not contain as discharged more than 3 parts per 100,000 of suspended matter, and with its suspended matters included must not take up at 65° F. (18.3° C.) more than 2 parts per 100,000 of dissolved oxygen in 5 days.

* Royal Commission on Sewage Disposal. Final Report, Feb. 11, 1915 [Cd. 7821].

TABLE GIVING THE AMOUNTS OF DISSOLVED OXYGEN IN DISTILLED WATER AT VARIOUS TEMPERATURES (BAR. 4760 mm.).^{*}

Temperature °C.	Oxygen (parts per 100,000).	Temperature °C.	Oxygen (parts per 100,000).	Temperature °C.	Oxygen (parts per 100,000).
0	1.42	11	1.09	21	0.86
1	1.39	12	1.07	22	0.85
2	1.36	13	1.04	23	0.85
3	1.32	14	1.02	24	0.84
4	1.28	15	1.00	25	0.82
5	1.24	16	0.98	26	0.81
6	1.22	17	0.96	27	0.80
7	1.19	18	0.94	28	0.80
8	1.17	19	0.92	29	0.79
9	1.14	20	0.90	30	0.78
10	1.11				

* Calculated from Roscoe and Lunt's table (*Trans. Chem. Soc.*, 1880, 569) for temperatures from 5-30° C. The values given for 0-4° are based on determinations by Winkler's process.

SAFETY TABLE FOR DETERMINING THE ORIGINAL GRAVITY OF
WORTS OF BEER BY THE DISTILLATION PROCESS.*

Spirit Indica- tion	Degrees of Original Specific Gravity	Spirit Indica- tion	Degrees of Original Specific Gravity	Spirit Indica- tion	Degrees of Original Specific Gravity	Spirit Indica- tion	Degrees of Original Specific Gravity
0	00 (g)	41	17.75 (d)	82	36.58 (j)	123	56.38 (k)
1	42 (a)	42	18.11 (e)	83	37.04 (k)	124	56.89 (l)
2	85 (b)	43	18.66 (d)	84	37.51 (l)	125	57.40 (m)
3	127 (a)	44	19.12 (e)	85	37.97 (m)	126	57.91 (n)
4	170 (b)	45	19.57 (f)	86	38.44 (n)	127	58.42 (o)
5	212 (a)	46	20.03 (f)	87	38.90 (o)	128	58.93 (p)
6	255 (b)	47	20.48 (g)	88	39.37 (p)	129	59.44 (q)
7	297 (a)	48	20.93 (g)	89	39.83 (q)	130	59.95 (r)
8	340 (b)	49	21.39 (h)	90	40.30 (r)	131	60.46 (s)
9	382 (a)	50	21.85 (h)	91	40.77 (s)	132	60.97 (t)
10	425 (b)	51	22.30 (i)	92	41.24 (t)	133	61.48 (u)
11	467 (a)	52	22.76 (i)	93	41.71 (u)	134	61.99 (v)
12	510 (b)	53	23.21 (j)	94	42.18 (v)	135	62.51 (w)
13	552 (a)	54	23.67 (j)	95	42.65 (w)	136	63.01 (x)
14	595 (b)	55	24.12 (k)	96	43.12 (x)	137	63.52 (y)
15	637 (a)	56	24.58 (k)	97	43.59 (y)	138	64.03 (z)
16	680 (b)	57	25.03 (l)	98	44.06 (z)	139	64.54 (aa)
17	722 (a)	58	25.49 (l)	99	44.53 (aa)	140	65.05 (ab)
18	765 (b)	59	25.94 (m)	100	45.00 (ab)	141	65.56 (ac)
19	807 (a)	60	26.40 (m)	101	45.48 (ac)	142	66.07 (ad)
20	850 (b)	61	26.86 (n)	102	45.95 (ad)	143	66.58 (ae)
21	891 (a)	62	27.32 (n)	103	46.43 (ae)	144	67.09 (af)
22	938 (a)	63	27.78 (o)	104	46.91 (af)	145	67.60 (ag)
23	982 (b)	64	28.24 (o)	105	47.38 (ag)	146	68.11 (ah)
24	1026 (b)	65	28.70 (p)	106	47.86 (ah)	147	68.62 (ai)
25	1070 (c)	66	29.16 (p)	107	48.33 (ai)	148	69.13 (aj)
26	1114 (c)	67	29.62 (q)	108	48.81 (aj)	149	69.64 (ak)
27	1158 (c)	68	30.08 (q)	109	49.28 (ak)	150	70.15 (al)
28	1202 (c)	69	30.54 (r)	110	49.76 (al)	151	70.66 (am)
29	1246 (c)	70	31.00 (r)	111	50.23 (am)	152	71.17 (an)
30	1290 (c)	71	31.46 (s)	112	50.71 (an)	153	71.68 (ao)
31	1334 (c)	72	31.93 (s)	113	51.18 (ao)	154	72.19 (ap)
32	1378 (c)	73	32.39 (t)	114	51.65 (ap)	155	72.70 (aq)
33	1422 (c)	74	32.86 (t)	115	52.13 (aq)	156	73.21 (ar)
34	1466 (c)	75	33.32 (u)	116	52.60 (ar)	157	73.72 (as)
35	1510 (c)	76	33.79 (u)	117	53.08 (as)	158	74.23 (at)
36	1554 (c)	77	34.25 (v)	118	53.55 (at)	159	74.74 (au)
37	1598 (c)	78	34.72 (v)	119	54.03 (au)	160	75.25 (av)
38	1642 (c)	79	35.18 (v)	120	54.50 (av)		
39	1686 (c)	80	35.65 (w)	121	54.98 (aw)		
40	1730 (c)	81	36.11 (w)	122	55.45 (ax)		

* This table, dated November 25, 1914, is the new official table incorporated in the Finance Act, 1914, and replaces the old official tables by Graham, Hofmann, and Redwood that have been in use since 1880.

	.01.	.02.	.03.	.04.	.05.	.06.	.07.	.08.	.09.
(a)	.04	.08	.13	.17	.21	.25	.29	.34	.38
(b)	.04	.09	.13	.17	.22	.26	.30	.34	.39
(c)	.04	.09	.13	.18	.22	.26	.31	.35	.40
(d)	.05	.09	.14	.18	.23	.27	.32	.36	.41
(e)	.05	.09	.14	.18	.23	.28	.32	.37	.41
(f)	.05	.09	.14	.19	.24	.28	.33	.38	.42
(g)	.05	.10	.14	.19	.24	.29	.34	.38	.43
(h)	.05	.10	.15	.20	.25	.30	.34	.39	.44
(i)	.05	.10	.15	.20	.25	.30	.35	.40	.45
(k)	.05	.10	.15	.20	.26	.31	.36	.41	.46
(l)	.05	.10	.16	.21	.26	.31	.36	.42	.47
(m)	.05	.11	.16	.21	.27	.32	.37	.42	.48
(n)	.06	.11	.17	.22	.28	.34	.39	.45	.50

The degrees of original gravity corresponding to spirit indications of 0.01–0.09 are shown in the sub-table above.

E.g. Spirit indication, 6.47. From the table 6.47 = 28.24 degrees of original gravity, and since this is lettered (a) reference to that line in the sub-table shows that 0.07 = 0.32 degree. Hence 6.47 spirit indication = 28.24 + 0.32 = 28.56 "degrees of gravity lost."

The table given on page 100, which has the force of law, supersedes the tables formerly used, and is due to Sir Edward Thorpe and Dr E. T. Brown working in co-operation. True indications of original gravity may be expected from its use, individual brewery data in the Reports† suggesting that it will more often underestimate than overestimate original gravity, but the extreme error should be $\pm 0.5\%$. For the purpose of the charge of duty the Finance Act of 1914 directs that a deduction of 0.75% shall be allowed in every case from original gravity determinations.

The authorities above mentioned state that fresh worts contain practically no acetic or other volatile acid, and that the amount produced during fermentation and storage is negligibly small so long as the beer remains sound. Hence the determination of acidity may be omitted with all sound beers. In those cases (*e.g.* strong ales which have become markedly acid) where the correction for acidity is necessary, the following table will be required:—

The lettering and sub table are additions by the author.

† See *Journ. Inst. Brewing*, 1914, 20, 569–713.

TABLE FOR ASCERTAINING THE VALUE OF THE ACETIC ACID.
Corresponding Degrees of "Spirit" Indication.

Excess per cent of Acetic Acid in the beer.	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09
0	1.00	1.02	1.04	1.06	1.07	1.08	1.09	1.11	1.12	1.13
1	1.14	1.15	1.17	1.18	1.19	1.21	1.22	1.23	1.24	1.26
2	1.27	1.28	1.29	1.31	1.32	1.33	1.34	1.35	1.37	1.38
3	1.39	1.40	1.42	1.43	1.44	1.46	1.47	1.48	1.49	1.51
4	1.52	1.53	1.55	1.56	1.57	1.59	1.60	1.61	1.62	1.64
5	1.65	1.66	1.67	1.69	1.70	1.71	1.72	1.73	1.75	1.76
6	1.77	1.78	1.80	1.81	1.82	1.84	1.85	1.86	1.87	1.89
7	1.90	1.91	1.93	1.94	1.95	1.97	1.98	1.99	1.10	1.02
8	1.03	1.04	1.05	1.07	1.08	1.09	1.10	1.11	1.13	1.14
9	1.15	1.16	1.18	1.19	1.21	1.22	1.23	1.25	1.26	1.28
1.0	1.29	1.31	1.33	1.35	1.36	1.37	1.38	1.40	1.41	1.42

The determination of acidity is best made by distillation in a current of steam and titration of the distillate. More conveniently, but somewhat less accurately, the volatile acid, calculated as acetic acid, is determined by the loss of acidity of a sample of the beer (50 c.c.) after evaporation to dryness over an open steam-bath.

The "spirit indication" corresponding to the acetic acid thus determined is added to that found by either the distillation or the evaporation process and the original gravity calculated as already described. When the proportion of volatile acid is very high, it affects the density of the distillate and so prevents the accurate determination of the spirit indication. In this case the distillate should be neutralised with sodium hydroxide solution and re-distilled.

Note.—The old official method (1880) of determining acidity by direct titration and subtraction of 0.1 per cent. from the acidity so found is not considered satisfactory. (Graham, Hofmann, and Redwood stated that fresh worts may contain 0.1 per cent. of acetic acid and that all acidity in excess of this amount may be regarded as acetic acid derived from the alcohol of the beer.)

Extract.—By dividing "extract gravity" less 1000 by 4.0 we obtain the weight in grams of dry extract in 100 c.c. of the beer.

Determination of Original Gravity by the (official) Distillation Process.—Worts & unfinished beers containing a sediment of yeast, etc., are required to be filtered before analysis.

A sample of beer is first freed from most of its dissolved carbon dioxide either by pouring it backward and forward from one vessel to another or by means of a mechanical whisk or stirrer. Its temperature is then adjusted to 60° F. and 100 c.c. (75 c.c. will suffice) measured out and transferred to a distilling flask, the measuring flask being rinsed out with about 20 c.c. of water and the rinsings added to the main quantity, which is then distilled. The distillate

is received in the measuring flask originally used, about four-fifths of the volume taken being collected. Its temperature is then carefully adjusted to 60° F. and made up to the mark with water also at 60°. The sp. gr. is then taken with a 50 c.c. bottle and the result subtracted from 1000. This gives the "spirit indication," and the corresponding number of "degrees of gravity lost" is found from the table on p. 100. The residue in the distilling flask is rinsed into another 100 c.c. (or 75 c.c.) flask, cooled, the temperature adjusted to 60° F., made up to the mark, and the sp. gr. determined. This is the "residue gravity" or "extract gravity." The original gravity is obtained by adding the "degrees of gravity lost" to the "residue gravity."

<i>Ex.</i> Sp. gr. of spirit distillate at 60°/60° F.	994.10
" " de-alcoholized beer	1014.94
("residue gravity")	
Spirit indication 1000 - 994.10	6.90
5.90 spirit indication - 25.91 "degrees of gravity lost"	
"Residue gravity"	1014.94
	<hr/>
	1010.88 original gravity

Determination of Original Gravity by the Evaporation Process.—In this method the amount of alcohol in a beer is determined from the difference between the sp. gr. of the original beer, freed from its dissolved carbon dioxide, and the sp. gr. of the residue after driving off the alcohol and making up to the original volume, both determinations being made at 60° F. 100 c.c. (or 75 c.c.) are evaporated by gentle boiling in a beaker or basin until the volume is reduced to between one-half and one third, care being taken that none of the solid matter is charred during the process. The cooled residue is transferred back to the measuring flask, the beaker or basin thoroughly rinsed into it, the temperature adjusted to 60°, and made up to the mark. The liquid is then well mixed and its sp. gr. taken. Results are calculated as shown in the example given below.

It has been proved experimentally that the spirit indication obtained as above is 0.16° less than that determined by distillation, the difference being very constant in amount and apparently independent of the actual original gravities of the beers. Hence, by an addition of 0.16° to the spirit indication found, the table on p. 100 may be used for the Evaporation Process also.

<i>Ex.</i> Sp. gr. of original beer at 60° F./60° F.	1008.64
" " evaporated " "	1014.74
("residue gravity")	
	<hr/>
	6.10
	+ .16
	<hr/>
Spirit indication	6.26

TABLE FOR SALT IN BEER.

From the statutory table 6.26 spirit indication
 — 27.32 + .28 — 27.60 "degrees of gravity lost"
 "residue gravity" = 1014.74
1012.31 original gravity.

TABLE FOR SALT IN BEER.

Salt in Grains per Gallon, corresponding to c.c. of Decinormal AgNO_3^{*}
 25 c.c. of Beer A be employed.

c.c. $\frac{N}{10} \text{AgNO}_3$	Grains NaCl per gallon.	c.c. $\frac{N}{10} \text{AgNO}_3$	Grains NaCl per gallon.	c.c. $\frac{N}{10} \text{AgNO}_3$	Grains NaCl per gallon.
0.1	1.64	2.2	36.04	4.2	68.80
0.2	3.28	2.3	37.67	4.3	70.43
0.3	4.91	2.4	39.31	4.4	72.07
0.4	6.55	2.5	40.95	4.5	73.71
0.5	8.19	2.6	42.59	4.6	75.35
0.6	9.83	2.7	44.23	4.7	76.99
0.7	11.47	2.8	45.86	4.8	78.62
0.8	13.10	2.9	47.50	4.9	80.26
0.9	14.74	3.0	49.14	5.0	81.90
1.0	16.38	3.1	50.78	5.1	83.54
1.1	18.02	3.2	52.42	5.2	85.18
1.2	19.66	3.3	54.05	5.3	86.81
1.3	21.29	3.4	55.69	5.4	88.45
1.4	22.93	3.5	57.33	5.5	90.09
1.5	24.57	3.6	58.97	5.6	91.73
1.6	26.21	3.7	60.61	5.7	93.37
1.7	27.85	3.8	62.24	5.8	95.00
1.8	29.48	3.9	63.88	5.9	96.64
1.9	31.12	4.0	65.52	6.0	98.28
2.0	32.76	4.1	67.16	6.1	99.92
2.1	34.40				

Note. The above table is useful in giving the amount of NaCl that may be present, calculated from the combined chlorine found. To obtain the actual amount of sodium chloride, the sodium present must also be determined.
 * 1 c.c. = 0.00685 gm. NaCl.

BLUNT'S MODIFICATION OF TABARIE'S FORMULA.

Tabarie's formula for directly determining alcohol in beer and wine from the sp. gr. of the original sample and of the boiled sample made up to the volume taken at the same temperature is

$$\text{sp. gr. of alcohol boiled away} = \frac{S}{S_b}$$

$$\text{where } S = \text{sp. gr. of original liquid} \\ S_b = \text{ " " boiled " " or "extract;"}$$

Blunt has shown* that a more correct result is obtained by using the formula

$$\text{sp. gr. of alcohol boiled away} = \frac{1}{1 + S - S_b}$$

This is fully confirmed by Helmer who found† that in all cases the results obtained by subtraction are closer to those obtained by distillation than are those by Tabarie's formula, and the results are better the greater the alcoholic strength.†

SPECIFIC ROTATORY POWER.

The specific rotatory power of an optically active substance in solution may be defined as the angle through which a plane polarized ray of light of definite refrangibility is rotated by a column one decimetre in length of a solution containing 1 gram of the substance in 1 c.c.

If the rotation is observed through a tube l decimetre in length, and the solution contains c grams of substance in 100 c.c., then, if α be the angle of rotation, the "specific rotatory power" is given by the formula

$$[\alpha] = \frac{\alpha \cdot 100}{l \cdot c}$$

The ray used and the temperature of the liquid are generally added, thus $[\alpha]_D^{20} = 66.6^\circ$ means that the specific rotatory power for ray D† at the temperature of 20° C. is 66.6°.

The specific rotatory power (or "specific rotation")‡ of liquid carbon compounds is given by the formula

$$[\alpha] = \frac{\alpha \cdot d}{l \cdot w}$$

Where l is the length of the observation tube in decimetres, d is the sp. gr. of the liquid referred to water at 4° C. as standard, in which case w expresses the weight in grams of 1 c.c.

* Analyst, 1891, 16, p. 221.

† Ibid., p. 223.

‡ Sodium flame.

In this country observations are commonly made at a temperature of 60° F., but on the Continent 20° C. is the "normal temperature" of observation. With many substances, however, a difference of 4·4° C. causes but little difference in the readings.

Molecular Rotation.—This term is applied to the product of the molecular weight (M) and specific rotation of a body divided by 100, and is represented by the symbol $[\alpha]$.

$$[\alpha] = \frac{M}{100} [\alpha]$$

The divisor 100 is used simply to avoid the use of inconveniently large numbers. $[\alpha]$ expresses the rotation which would result if each c.c. of the solution contained 1 gram molecule of the active substance and the length of the liquid column were 1 mm.

Mutirotaion.—Freshly prepared solutions of a number of the sugars show a rotatory power different from that of the same solution on standing, undergoing either an increase or decrease until finally a constant value is reached. This phenomenon is termed *mutirotaion* or *mutarotation*.

Originally the term *bi-rotation* was used, as the observation was made that a dextrose solution when freshly prepared gave about twice the reading of the same solution after standing.

At the ordinary temperature a period of from six to twenty four hours is usually required, but by boiling the transformation to the stable form is completed in a few minutes.* Dextrose, lactose, and maltose show this behaviour, maltose giving with a freshly made solution a lower reading than that observed after standing for some hours. Sucrose does not show this effect.

Observations are usually made with a polarimeter, such as Laurent's half-shadow instrument, for which homogeneous light, generally a sodium flame, is required; or with a Soleil-Ventzke-Scheibler Colour Saccharimeter, which is adapted for use with white light illumination from oil or gas lamps; or with a modern Half-shadow Saccharimeter,† in which the field of view is divided into two surfaces, each of which alternately becomes perfectly dark as the analyser is rotated, the point sought, and at which the reading is taken, being that at which the two surfaces show exactly the same degree of illumination or partial shadow. White light is used.

Specific rotatory power as determined by the (more or less obsolete) Soleil-Ventzke-Scheibler Colour Saccharimeter is indicated by $[\alpha]_j$, where j is the *transition tint* (i.e. from the blue to the red), and is the ray complementary to the medium yellow or *jaune moyen*—hence the j . This *jaune moyen* ray is the true medium

* The same result is also attained by adding a few drops of strong ammonia before making up the volume of the solution.

† In the latest type of polarimeter, the optical field is divided into 3 parts instead of 2, as in the half-shadow instruments. Such instruments are more accurate, the equality of the field being capable of a more delicate adjustment. These "have properly displaced the colour instruments completely: the part of these in saccharimetry has been played, and for good" (Dr. Schourack).

yellow of the solar spectrum; its wave length is 0.0005608 millimetres.* The Ventzke scale is such that 100 divisions equal the amount of rotation caused by a "normal sugar solution," 200 mm. in length, at 17.5° C. Ventzke proposed a method of preparing this solution which was intended to render the use of a balance unnecessary. He defined the normal sugar solution as a solution of pure sugar in water which should have at 17.5° C. the sp. gr. of 1.100, water at 17.5° being unity. To determine then the polarizing sugar of any substance, it would simply be necessary to prepare a solution of it having this density as shown by a hydrometer. But this method was soon abandoned, because the salts in the cases sugars to be investigated have a density different from that of sugar itself, and hence cause erroneous results. As, however, the 100 point of many saccharimeters had already been fixed by aid of the normal sugar solution of 1.1 sp. gr., and as it was desirable not to change the scale once introduced, the concentration of the Ventzke normal solution at 17.5° was then determined, and it was found that 100 c.c. of such a solution contained 26.018 grams of sugar; thus the *normal weight* should be 26.018 grams.

The above remarks apply only to the original Ventzke instruments. Since 1900 the *normal weight* has been altered to 26.0 grams, and the *normal sugar solution* is prepared as follows:

26 grams of chemically pure dry sugar are dissolved in water at 20° C. in a flask graduated to contain 100 true c.c. The solution is made up to the mark, well mixed, filtered if necessary, and polarized in a 200 mm. tube at 20° C. The reading should be 100 scale-divisions, and each scale-division indicates 0.20 gram of sucrose.

FACTORS FOR THE CONVERSION OF $[\alpha]_D$ INTO $[\alpha]_H$ AND *vice versa*

To convert $[\alpha]_D$ into $[\alpha]_H$, multiply by 1.111 (log. 0.04574) or *add one fourth*.

To convert $[\alpha]_H$ into $[\alpha]_D$, multiply by 0.9 (log. 1.95429) or *subtract one tenth*.

Thus if $[\alpha]_D = 20.2^\circ$, then $[\alpha]_H = 20.2 + 22.1 = 22.1^\circ$.
 If $[\alpha]_H = 57^\circ$, then $[\alpha]_D = 57 - 5.7 = 51.3^\circ$.

$$\begin{aligned} \text{[Landolt gives } [\alpha]_D &= \frac{21.5}{21.72} [\alpha]_H = 1.128 [\alpha]_H \\ [\alpha]_H &= \frac{21.72}{21.5} [\alpha]_D = 1.088 [\alpha]_D \end{aligned}$$

In the Soleil Ventzke-Schöbler Saccharimeter 100 scale-divisions equal 38.43° for ray J, or

$$1 \text{ scale-division} = 0.3843^\circ (\log. 1.581679).$$

* The wave length of D is 580 $\mu\mu$.

Hertzfeld and Schonrock found that at 20°C ,
100 scale divisions Ventzke = 31657 circular degrees for
sodium light;
or scale divisions Ventzke $\times 0.31657$ = circular degrees for sodium
light.

Figure . . . 1° angular rotation D = 2.8854 scale-divisions Ventzke.

The values representing specific rotation vary directly as the sp. gr.
divisor (D) used. Thus, if 151 be the specific rotation of maltose
for $[\alpha]_{\text{D}}^{\text{20}}$ (that is, on the basis of the 3.86 divisor), the specific rota-
tion where the divisor 3.92 is used will be $\frac{151 \times 3.92}{3.86} = 153.3^{\circ}$.

The number of grams per 100 c.c. of a solution of a carbohydrate
of which the sp. gr. at $15.5/15.5^{\circ}\text{C}$. is known (water = 1000) is found
by dividing the sp. gr. minus 1000 by a divisor (D) given in the
subjoined table. (A complete set of divisors for various concentrations
is given on p. 113.)

TABLE SHOWING THE SPECIFIC ROTATORY POWERS OF THE PRINCIPAL
CARBOHYDRATES IN 10 PER CENT. SOLUTION AT 20°C (-68°F).

Substance.	Formula.	Divisor to get grams per 100 c.c.	Specific rotatory power (absolute).		Specific rotatory power reduced to the common divisor 3.86.	
		D	$[\alpha]_{\text{D}}$	$[\alpha]_{\text{D}}$	$[\alpha]_{\text{H}_2\text{O}}$	$[\alpha]_{\text{H}_2\text{O}}$
Sucrose	$\text{C}_{12}\text{H}_{22}\text{O}_{11}$	3.86	+ 66.5	+ 73.8*	+ 66.5	+ 73.8
Dextrose (d-Glucose)	$\text{C}_6\text{H}_{12}\text{O}_6$	3.82	+ 52.7	+ 58.6	+ 53.3	+ 59.2
Levulose (d-Fructose)	"	3.92	- 93.8	- 104.2	- 92.4	- 102.6
Invert Sugar	$\text{C}_6\text{H}_{12}\text{O}_6 + \text{C}_6\text{H}_{12}\text{O}_6$	3.87	- 20.55	22.8	20.5	22.7
Maltose	$\text{C}_{12}\text{H}_{22}\text{O}_{11}$	3.92	+ 138	+ 153.3	+ 135.9	+ 150.4
Dextrin	$(\text{C}_6\text{H}_{10}\text{O}_5)_n$	3.95	+ 200	+ 222.2	+ 195.4	+ 217.1
Lactose	$\text{C}_{12}\text{H}_{22}\text{O}_{11}$	3.71	+ 52.5	58.3	...	...
(cryst.).	H_2O					
Lactose (anhyd.)	$\text{C}_{12}\text{H}_{22}\text{O}_{11}$	3.91	+ 55.3	+ 61.4	...	...

Note. At the meeting of the International Commission for unifying methods of
sugar analysis, held in Paris in 1900, the normal temperature of 20°C was adopted
and all measuring vessels are required to be graduated in true c.c. at this temperature.

* According to J. Heron, the common divisor 3.86 gives total solids correctly only
in those cases where the sp. gr. of the solution lies between 103.5 and 1040. For
solutions containing more than 12 grams of solids per 100 c.c. the divisor 3.85 gives
closer results.

SOLEIL-VENTZKE-SPIRITUEL-SACCHARIMETER 200-MM. TUBE USED:
TRANSITION TINT.

1 gram in 100 c.c. of	Scale divisions of deviation at 20° C. †	
	For absolute divisions	For % solution.
Cane sugar	+ 5.81‡	+ 5.81
Dextrose	+ 9.5	+ 9.08
Lactulose	- 5.42	- 5.34
Invert sugar	- 4.19	- 4.18
Maltose	+ 7.98	+ 7.85
Dextrin	- 11.36	- 11.30
Lactose (cryst.)	.. 0.5	..
.. (anhyd.)	+ 3.20	..
Gallisin	..	+ 4.85

* $C_{12}H_{22}O_{11} \cdot H_2O$.

† The number of scale-divisions is obtained by dividing the (arc-angle) case by 19°215 (log 1.283645).

‡ When inverted this becomes - 1.25

	Multipher	Logarithm
To convert $C_{12}H_{22}O_{11}$ into $C_{12}H_{20}O_{10}$	$\frac{360.192}{342.176} = 1.053$	0.02298
$C_{12}H_{22}O_{12}$.. $C_{12}H_{20}O_{10}$	$\frac{342.176}{360.192} = 0.95$	1.97772
$C_{12}H_{20}O_{10}$.. $C_{12}H_{22}O_{12}$	$\frac{360.192}{342.176} = 1.051$	0.04577
	or add one .. ninth	
$C_{12}H_{24}O_{12}$.. $C_{12}H_{20}O_{10}$	$\frac{360.192}{324.16} = 1.11$	1.04523
	or deduct one-tenth	

The following examples show the methods employed in solving problems connected with this subject.

Ex. I. To find a formula for calculating the amount of cane-sugar present in a mixture of cane-sugar and dextrose when the specific rotatory power (ray β) before and after inversion are known.

Let R_b be the specific rotatory power before inversion

R_a be the specific rotatory power after inversion

and let x be the percentage of cane-sugar present.

Then $100 - x$ is the percentage of dextrose present.

$$\begin{aligned} \text{Hence } 100 R_b &= 13.8x + (100 - x) 58.6 \\ \text{and } 100 R_a &= 21.0x + (100 - x) 58.6 \\ \therefore \frac{100 R_b - R_a}{R_b - R_a} &= 97.8x. \\ x &= \frac{R_b - R_a}{.978}. \end{aligned}$$

Similarly when we have given the scale degrees (D) before and after inversion, the 200 mm. tube being used

$$\text{Grams of cane-sugar per 100 c.c. of solution} = \frac{D_b - D_a}{.509}.$$

Ex. II. Determination of cane-sugar in mixtures of cane- and invert-sugar only.

The method now universally adopted is Herzfeld's modification of Clerget's process.* It is carried out as follows: Dissolve the normal weight (26.048 grams) of the sample to be examined in water and make up to 100 c.c., decolorizing and filtering if necessary, and polarize at 20° C. Transfer 50 c.c. of this solution to a 100-c.c. flask, add 5 c.c. strong (38%) hydrochloric acid and about 20 c.c. of water. Well shake the flask and immerse in a bath of water at the temperature of 70° C., at the same time putting a thermometer in the flask: when the temperature of the sugar solution has reached 68°–70° C., which it should do in five minutes, the flask is kept in the water-bath at this temperature for five minutes longer, then taken out, cooled down quickly to the normal temperature, diluted with water to 100 c.c., polarized at 20° C., and the reading multiplied by two on account of the dilution of the liquid.

Herzfeld found that pure cane-sugar treated as above showed a change of rotation on a Soleil-Ventzke-Scheibler Saccharimeter of 132.66 divisions at 20° C. Hence –

$$\text{Cane-sugar \%} = \frac{100 (\text{direct} - \frac{1}{2} \text{inverted reading})}{132.66}.$$

But, since the algebraical difference here becomes the *sum* of the two readings without regard to sign, and $100/132.66 = 0.7539$

$$\begin{aligned} \text{Cane-sugar \%} &= 0.7539 \times (\text{sum of readings}) \\ &[\log .0.7539 = \bar{1}.87729]. \end{aligned}$$

This method is only applicable when other sugars, inulins, starches, and glucosides, which are also inverted by acids, are not present. When such bodies are present, hydrolysis may be effected by the use of invertase. † Now 26.0 grams.

If, instead of 20° C., the readings before and after inversion are made at t ° C.,

$$\text{Cane-sugar } \alpha_D = \frac{100(\text{direct} - \text{inverted reading})}{142.63 - \frac{t}{2}}$$

Ex. III. Determination of dextrose and maltose in the cupric reducing power and optical activity for "optical" of a solution before and after fermentation.

As an example we may take a commercial "Glucose," which gave the following results:—

Cupric reduction before fermentation	78.85 %
" after "	6.62 "
	<hr/>
	72.23
Opticity before fermentation	40.98° [α] _D
" after "	11.24 "
	<hr/>
	29.74

By fermentation dextrose and maltose are converted and the differences between the cupric reductions and between the optivities before and after fermentation give measures of the amounts of the two sugars present. Hence, if D and M be the percentages of dextrose and maltose present respectively, we have (taking 62 as the K of maltose):—

$$\begin{aligned} 62 \text{ M} + 100 \text{ D} &= 72.23 \quad (1) \\ 138 \text{ M} + 52.7 \text{ D} &= 38.74 \quad (2) \end{aligned}$$

$$(1) \times 138 \quad 85.56 \text{ M} + 13800 \text{ D} = 9967.1$$

$$(2) \times 62 \quad 85.56 \text{ M} + 3267 \text{ D} = 2401.88$$

$$10533 \text{ D} = 7565.86$$

$$\text{D} = \frac{7565.86}{10533} = 71.83$$

$$\text{From (1)} \quad 62 \text{ M} = 72.23 - 71.83 = 0.40$$

$$\text{M} = \frac{0.40}{62} = 0.65$$

$$\begin{aligned} \text{Result: Dextrose } &71.8 \% \\ \text{Maltose } &0.6 \% \end{aligned}$$

POLARIMETER READINGS. - REDUCTION OF MINUTES TO DECIMALS
OF A DEGREE.

Minutes	Decimal equiva- lent.	Minutes.	Decimal equiva- lent.	Minutes.	Decimal equiva- lent.	Minutes.	Decimal equiva- lent.
1	.017	16	.267	31	.517	46	.767
2	.033	17	.283	32	.533	47	.783
3	.05	18	.3	33	.55	48	.8
4	.067	19	.317	34	.567	49	.817
5	.083	20	.333	35	.583	50	.833
6	.1	21	.35	36	.6	51	.85
7	.117	22	.367	37	.617	52	.867
8	.133	23	.383	38	.633	53	.883
9	.15	24	.4	39	.65	54	.9
10	.167	25	.417	40	.667	55	.917
11	.183	26	.433	41	.683	56	.933
12	.2	27	.45	42	.7	57	.95
13	.217	28	.467	43	.717	58	.967
14	.233	29	.483	44	.733	59	.983
15	.25	30	.5	45	.75		

TABLE GIVING DIVISORS IN TO 100 GRAMS PER 100 C.C. OF CERTAIN SUGAR SOLUTIONS OF KNOWN DENSITY. (H. T. Brown and Edward Jones.)

Sp. gr. at 15.5°/15.5° C.	Sucrose	Dextrose	Lactulose	Invert sugar	Maltose
1005	3.870	3.844	3.932	3.896	3.941
1010	3.869	3.843	3.929	3.894	3.939
1015	3.868	3.841	3.925	3.888	3.936
1020	3.867	3.840	3.922	3.886	3.934
1025	3.865	3.838	3.928	3.885	3.934
1030	3.865	3.836	3.924	3.880	3.929
1035	3.864	3.834	3.921	3.877	3.926
1040	3.863	3.832	3.917	3.874	3.924
1045	3.861	3.830	3.914	3.871	3.923
1050	3.860	3.826	3.910	3.868	3.918
1055	3.858	3.824	3.906	3.865	3.916
1060	3.857	3.821	3.902	3.861	3.913
1065	3.855	3.817	3.899	3.857	3.910
1070	3.854	3.814	3.895	3.855	3.907
1075	3.852	3.810	3.892	3.851	3.905
1080	3.851	3.807	3.888	3.847	3.902
1085	3.849	3.803	3.884	3.843	3.899
1090	3.846	3.799	3.880	3.839	3.896
1095	3.844	3.796	3.876	3.836	3.893
1100	3.842	3.792	3.872	3.832	3.890

Note. In the above table the sp. gr. is taken at 15.5° C., and referred to water at the same temperature. To get grams per 100 true c.c. multiply by the factor 0.99802, thus reducing the quantities by about 0.2 per cent.*

Ex. A solution of sucrose of sp. gr. 1030 at 15.5° C. contains $30/3.865 = 7.762$ grams of dry sugar in 100 c.c. Hence 100 c.c., which weigh 103 gm., contain $103 - 7.762 = 95.238$ gm. of water. The volume of the sugar will be $100 - 95.238 = 4.762$ c.c. (taking c.c. to mean the volume occupied by 1 gm. of water at 15.5° C.) and its specific volume (*i.e.* volume occupied by 1 gm.) $4.762/7.762 = 0.6135$ c.c.

Also $1 - 0.6135 = 0.3865$, which is one tenth of the original divisor, so that if $V =$ specific volume of the dissolved sugar, $D = 10(1 - V)$ and $V = \frac{10 - D}{10}$.

* Thus, the weight of the volume of water at 15.5° C. to which all the densities are referred is 100 grams weighed in air. Reduced to a vacuum this will weigh 100.106 grams, and as the density of water at 15.5° C. is 0.99808 as compared with that of water at 4° C., the true volume of the 100 "reputed" c.c. at 15.5° will be $\frac{100.106}{0.99808}$

$= 100.198$ c.c. Hence the factor required is $\frac{100}{100.198} = 0.99802$.

CUPRIC OXIDE REDUCING POWERS OF THE CARBOHYDRATES.

Definition.—"Dextrose being the type of reducing bodies and the substance for which the amount of cupric oxide reduced was first determined, I use it as the standard to which to refer all other reducing carb. hydrates or mixtures of reducing with non-reducing ones. I take the cupric oxide reducing power (or 'cupric reducing power') of a body or mixture to be the amount of cupric oxide, calculated as dextrose, which 100 parts reduce: it is designated by the letter K."—(*O'Sullivan*).

Briefly, we may define "K" as the specific cupric reducing power of a substance referred to dextrose as standard (100). The division is often added: thus $K_{386} = 25$ means that the cupric reducing power of the substance is one-fourth that of dextrose when the solid matter is determined by the 386 divisor.

Preparation of Fehling's Solution: for Gravimetric Determinations.—Dissolve 34.6 grams of pure recrystallized copper sulphate in distilled water and make up the volume to 500 c.c. Then dissolve 173 grams Rochelle salt and 65 grams anhydrous sodium hydroxide in separate beakers, mix the solutions, and make up the volume with distilled water to 500 c.c. These two solutions are kept in separate bottles and are mixed in equal volumes, to form Fehling's solution, immediately before use.

Method of making a determination of cupric reducing power. Fifty c.c. of the freshly mixed Fehling's solution are placed in a beaker of about 250 c.c. capacity, and having a diameter of 7.5 cm. (3 inches). This is placed in a boiling water-bath, and when the solution has attained the temperature of the water, the accurately weighed or measured volume of the sugar solution is added, and the whole made up to 100 c.c. with boiling distilled water. The beaker, which is covered with a clock glass, is then returned to the water-bath and the heating continued for exactly twelve minutes. The precipitated cuprous oxide is now rapidly filtered off through a Soxhlet tube, washed first with hot water, then with alcohol and ether, and finally dried. When dry, the cuprous oxide is reduced to metallic copper by gently heating in a stream of hydrogen, and weighed; or it may be oxidized in a stream of oxygen and weighed as CuO . Sometimes the Cu_2O is weighed as such, after being dried in a water oven (see *O'Sullivan and Stern, Jour. Chem. Soc., 1896, p. 1692*).

As spontaneous reduction of Fehling's solution invariably takes place, the amount of this must be carefully determined for every fresh batch of the solution and allowed for in each determination of cupric reducing power. It usually amounts to 0.002 to 0.003 gram CuO per 50 c.c. of Fehling's solution used.

It is of great importance, in making the above determination, that an amount of the reducing sugar is taken that will give a weight of CuO lying between 0.15 and 0.35 gram.

It must be carefully borne in mind that the values given in the following Tables are correct only when the preparation of the Fehling's solution, and the manner of carrying out the determination of cupric reducing power conform exactly with the direction given on p. 114. It has been shown that the amount and nature of the alkali in Fehling's solution exercises a great influence on the quantity of copper reduced by a given weight of maltose or of the starch-transformation products; but with dextrose and laevulose this influence is far less. Glendinning⁶ has proved that an equivalent amount of potassium hydroxide may be substituted for the sodium compound without causing any alteration in the reducing power. In the case of dextrose and laevulose the variant which has the greatest influence is the state of dilution of the Fehling's solution. When the dilution is greater than that prescribed in the standard method, the reducing power is appreciably lower, and the greater the dilution the greater the difference.

The standard conditions given in detail above are those prescribed by Brown, Morris, and Mellar and have found wide acceptance. Results are calculated by means of Tables A. and B. (see pp. 116, 117), both of which are given in their original papers.⁷ Absolute values are given in each case.

The following factors are also useful

			Logarithm
Sucrose (after inversion)	CuO	0.4079	1.6119
Starch or dextrin (after hydrolysis)	CuO	0.5750	1.67493
Lactose (anhydrous)	CuO	0.5781	1.76223
" (cryst.)	CuO	0.6088	1.78451
Arabinose	CuO	0.4600	1.66206
Xylose	CuO	0.4167	1.62175

Rules to find the values of "K" when referred to different divisors.

When the true divisor is used to determine grams of sugar per 100 c.c., the K so obtained is called *absolute*. Frequently, however, $K_{3.86}$ —that is, the relative cupric reducing power when the divisor 3.86 is used to get grams of sugar per 100 c.c.—is required. Thus 1.372 grams CuO = 1 gram of absolute maltose, then for 1 gram of 3.86 maltose we should have

$$1.372 \times \frac{3.86}{3.92} = 1.351 \text{ gram CuO.}$$

Let the true divisor to get grams per 100 c.c. be M, then

$$K_{\text{absolute}} = \frac{K_{3.86} \times M}{3.86}.$$

⁷ See *Journ. Chem. Soc.*, 1897, 71, 52-123 and 276-284.

TABLE A

Weight of re- ducing sugar	Dextrose.		Laevulose		Invert sugar.		Maltose.	
	CuO obtained.		CuO obtained		CuO obtained		CuO obtained	
mgrams.	grams.		grams		grams		grams.	
50	0.1289		0.1155		0.1221		...	
55	0.1422		0.1287		0.1345		...	
60	0.1552		0.1407		0.1474		...	
65	0.1682		0.1521		0.1598		...	
70	0.1809		0.1645		0.1721		0.0966	
75	0.1935		0.1761		0.1840		0.1021	
80	0.2061		0.1881		0.1963		0.1102	
85	0.2187		0.1993		0.2084		0.1169	
90	0.2269		0.2114		0.2200		0.1237	
95	0.2420		0.2224		0.2317		0.1305	
100	0.2538		0.2351		0.2430		0.1373	
105	0.2662		0.2477		0.2550		0.1441	
110	0.2781		0.2558		0.2668		0.1509	
115	0.2900		0.2669		0.2783		0.1576	
120	0.3014		0.2777		0.2898		0.1641	
125	0.3133		0.2887		0.3009		0.1712	
130	0.3241		0.2997		0.3121		0.1779	
135	0.3354		0.3109		0.3232		0.1848	
140	0.3463		0.3209		0.3349		0.1916	
145	0.3573		0.3311		0.3448		0.1983	
150	0.3673		0.3409		0.3546		0.2051	
155	0.3787		0.3517		0.3655		0.2119	
160	0.3891		0.3622		0.3761		0.2186	
165	0.3996		0.3726		0.3869		0.2251	
170	0.4098		0.3828		0.3971		0.2323	
175	0.4200		0.3930		0.4076		0.2390	
180	0.4302		0.4032		0.4177		0.2458	
185	0.4399		0.4134		0.4276		0.2526	
190	0.4501		0.4231		0.4376		0.2593	
195	0.4599		0.4335		0.4476		0.2661	
200	0.4689		0.4431		0.4570		0.2729	

If Cu is weighed instead of CuO the equivalent amount of the latter is easily obtained, thus: Increase the weight of Cu by one-fourth and then by one-hundredth of the latter, the result is the CuO required, from which the reducing sugar is obtained by the above table.

Ex.

$$\begin{array}{rcl}
 & \text{Cu} & 0.1584 \\
 + \frac{1}{4} \text{th} & & 0.0396 \\
 + \frac{1}{100} \text{ of } \frac{1}{4} \text{th} & & 0.0004 \\
 \hline
 & & 0.1984 \text{ CuO,}
 \end{array}$$

which corresponds, e.g., to 77 mgrms. of dextrose or 145 mgrms. of maltose

TABLE B.

Weight of reducing sugar	CuO corresponding to 1 gram of			
	Dextrose	Lactulose	Invert-sugar	Maltose
mgrams.	grams	grams	grams	grams
50	2.568	2.569	2.442	..
55	2.585	2.591	2.452	..
60	2.587	..	2.457	..
65	2.589	2.596	2.459	..
70	2.585	2.590	2.456	1.3800
75	2.580	2.589	2.454	1.3796
80	2.577	2.591	2.454	1.3792
85	2.572	2.585	2.451	1.3788
90	2.556	2.569	2.445	1.3784
95	2.551	2.564	2.442	1.3780
100	2.548	2.561	2.440	1.3777
105	2.545	2.561	2.439	1.3775
110	2.548	2.565	2.445	1.3769
115	2.522	2.529	2.435	1.3765
120	2.512	2.519	2.415	1.3761
125	2.504	2.510	2.407	1.3757
130	2.493	2.505	2.400	1.3753
135	2.484	2.500	2.394	1.3750
140	2.473	2.491	2.385	1.3746
145	2.464	2.481	2.378	1.3742
150	2.448	2.475	2.364	1.3738
155	2.445	2.469	2.365	1.3735
160	2.432	2.464	2.352	1.3731
165	2.422	2.458	2.345	1.3727
170	2.410	2.452	2.336	1.3723
175	2.400	2.445	2.329	1.3719
180	2.390	2.440	2.320	1.3715
185	2.377	2.434	2.311	1.3711
190	2.369	2.428	2.303	1.3708
195	2.358	2.423	2.295	1.3704
200	2.344	2.416	2.285	1.3700

Ex. Suppose that in a determination of dextrose 0.2000 gram of CuO was obtained. From Table A we find that this amount equals 115 mgrams. of dextrose; and by Table B, in the column giving dextrose, the figures 2.522 opposite 115 mgrams. show that 2.522 grams of CuO correspond to 1 gram of dextrose.

The following volumetric method, due to Lin and Rundle, is claimed to be quite as accurate as the gravimetric method already described and has the advantage of being far more rapid. The average error is 1 part in 300.

Fehling's solution is used and is made as follows:—

Solution No. 1.—Dissolve 64.25 grams of pure copper sulphate crystals in water and make up to 1 litre.

Solution No. 2.—316 grams of Rochelle salt are dissolved in hot water, 142 grams of caustic soda dissolved separately, the two solutions mixed in a litre flask, cooled and made up to the mark.

Equal volumes of these two solutions are accurately measured out at 15.5° C., and mixed in a dry flask immediately before use. The mixture constitutes the solution from which measured quantities are taken for titration.

The indicator is prepared as follows: 1.5 grams of ammonium thiocyanate and 1 gram of ferric ammonium sulphate are dissolved in 10 c.c. of water, 2.5 c.c. of conc. hydrochloric acid added, and the solution decolorized by the cautious addition of zinc dust. The indicator when kept for some time again develops the red (ferric) colour due to atmospheric oxidation, and must again be reduced. When decolorized too often in this way, the indicator loses sensitiveness.

Method of Procedure.—10 c.c. of Fehling's solution are pipetted into a 200 c.c. boiling flask and raised to boiling. The sugar solution, which should be adjusted to such a strength that 20 to 30 c.c. of it are required to reduce 10 c.c. of Fehling's solution, is then run into the boiling (undiluted) liquid in small amounts, commencing with 5 c.c. After each addition of sugar solution the mixture is boiled, the liquid being kept rotated. About a dozen drops of the indicator are placed on a white porcelain plate, and when it is judged that the precipitation of cuprous oxide is complete, a drop of the liquid is withdrawn by a glass rod or a capillary tube, and brought into contact with a drop of the indicator on the plate. The test must be carried out rapidly. The titration must be performed as rapidly as possible, as an atmosphere of steam is then kept in the neck of the flask and the influence of atmospheric oxygen avoided. At the final point, the liquid is boiled for about ten seconds. The first titration may give only an approximate result, and a second or third be necessary to establish the end-point accurately. One titration takes from 2½ to 3 minutes. The titration can be carried out by artificial light (incandescent gas or electric light).

The Fehling's solution is standardized as follows: Dissolve 0.95 gram of pure sucrose in water (150 c.c.), add 3½ c.c. of N/2 HCl, and boil the mixture for one minute. Cool, add 30 c.c. N/2 sodium hydroxide solution and make up with water to 500 c.c. This solution, which contains 0.2 gram of invert sugar per 100 c.c., is then titrated with 10 c.c. portions of Fehling's solution as above. (About 25.5 c.c. of the former solution will be required.) The value of the solution in terms of dextrose, maltose, etc., is determined in a similar manner. Every preparation of Fehling's solution will need standardizing. Results are calculated by the following table.

LING AND JONES'S TABLE FOR USE WITH FEHLING'S SOLUTION.

Volume of sugar solution required by 10 c.c. of Fehling's solution.	Dextrose.		Laeulose.		Invert Sugar.		Maltose.	
	D. Dextrose in 100 c.c. of solution.	D. Fehling's solution equivalent to 1 gm. of dextrose.	L. Laeulose in 100 c.c. of solution.	L. Fehling's solution equivalent to 1 gm. of laeulose.	I. Invert sugar in 100 c.c. of solution.	I. Fehling's solution equivalent to 1 gm. of invert sugar.	M. Maltose in 100 c.c. of solution.	M. Fehling's solution equivalent to 1 gm. of maltose.
c.c.	gram.	c.c.	gram.	c.c.	gram.	c.c.	gram.	c.c.
20	0.2427	206.0	...	...	...	...	...	...
21	0.2332	205.1	...	...	...	...	...	...
22	0.2226	204.2	0.2411	188.5	0.2112	197.5	0.3888	122.5
23	0.2138	203.4	0.2312	188.0	0.2311	196.8	0.3711	...
24	0.2056	202.6	0.2222	187.5	0.2218	196.0	0.3560	...
25	0.1981	201.9	0.2138	187.1	0.2132	195.5	0.3402	...
26	0.1911	201.3	0.2060	186.7	0.2052	194.9	0.3266	...
27	0.1846	200.7	0.1988	186.3	0.1980	194.3	0.3140	...
28	0.1784	200.1	0.1921	186.0	0.1910	193.9	0.3023	...
29	0.1728	199.6	0.1857	185.6	0.1846	193.4	0.2915	...
30	0.1675	199.1	0.1798	185.4	0.1787	193.0	0.2815	...
31	0.1625	198.6	0.1743	185.1	0.1731	192.5	0.2721	...
32	0.1577	198.2	0.1691	184.8	0.1678	192.2	0.2633	...
33	0.1532	197.8	0.1642	184.6	0.1629	191.8	0.2551	...
34	0.1490	197.4	0.1596	184.3	0.1583	191.5	0.2474	...
35	0.1450	197.0	0.1552	184.1	0.1539	191.2	0.2401	...
36	0.1412	196.7	0.1511	183.9	0.1497	190.9	0.2332	...
37	0.1377	196.4	0.1472	183.6	0.1458	190.6	0.2268	...
38	0.1343	196.0	0.1435	183.4	0.1424	190.3	0.2206	...
39	0.1310	195.8	0.1399	183.3	0.1385	190.1	0.2148	...
40	0.1279	195.5	0.1366	183.1	0.1349	189.8	0.2093	...
41	...	...	0.1334	182.9	0.1319	189.6	0.2041	122.5
42	...	...	0.1298	182.8	0.1288	189.4	...	...
43	...	...	0.1274	182.6	0.1259	189.2	...	...

See *The Analyst*, 1908, 33, 166. This table was constructed on the basis of a preparation of Fehling's solution of which 10 c.c. require 25.65 c.c. of a 0.2 per cent. solution of invert sugar.

Examples showing the use of the above table.

(i) Suppose that 25.0 c.c. of a solution of pure laeulose are required to reduce 10 c.c. of Fehling's solution. The figure in the column under L and opposite 25, viz. 0.2138, gives the grams of laeulose in 100 c.c. of the solution.

(ii) Suppose that for 10 c.c. of Fehling's solution 32.7 c.c. of a solution of pure dextrose are required. Then the grams of dextrose in 100 c.c. of the solution will be

$$0.1577 - (0.1577 - 0.1532) \times 7 = 0.1577 - 0.0032 = 0.1544.$$

(iii) The numbers given in columns D, L, I, and M are used

when separate determinations of two reducing sugars in a mixture, e.g. commercial invert sugar, are required. In these cases polarimetric observations are necessary, in addition to the determination of cupric-reducing power. A fully worked-out example of the calculation of percentages of dextrose and laevulose respectively from data so obtained is given in *The Analyst*, 1908, 33, 166 *et seq.*

ALCOHOLOMETRY.

Alcoholometry is the process of determining the strength of alcohol or the percentage of absolute alcohol in a spirituous mixture.

The following Table, which is believed to be the most accurate in existence, is a shortened form * of that compiled by Mr T. J. Cheater and Mr John Holmes, of the Government Laboratory, London, under the direction of Sir Edward Thorpe, F.R.S., who was then its Principal. In it are incorporated the results of the researches of four authorities, viz., Mendeleeff (1865), whose work "admittedly constitutes the most comprehensive and exact of the researches hitherto made in the field of alcoholometry"; Blagden and Gilpin (1790-91); Drinkwater (1848); and the Kaiserliche Normal Eichungs Kommission (Berlin, 1889). The basis of the Table is Mendeleeff's alcohol of sp. gr. 0.79359 at 15.6°/15.6° C. in air.

Proof Spirit.—In the assessment of duty and in commercial transactions the standard of strength is termed "proof." Spirit of proof strength is defined by statute (58 Geo. III. c. 28) as "that which at a temperature of 51° F. weighs exactly $\frac{1}{17}$ ths of an equal measure of distilled water" alcohol 51° F. The sp. gr. of proof spirit at 60° F. (32° F.) is 0.91276, and it contains 49.28 per cent. by weight and 57.10 per cent. by volume of anhydrous (or absolute) alcohol. Spirits of higher alcoholic content are said to be of overproof strength (o.p.) and those of lower alcoholic content of underproof strength (u.p.).

To find percentage of proof spirit :

(a) In spirits of overproof strength : add 100 to the percentage overproof, thus :

Sp. gr. 0.8120 = 68.28 per cent. o.p. and contains 168.28 per cent. of proof spirit. 100 vols. of this spirit, when diluted with water, will give 168.28 vols. of proof spirit.

(b) In spirits of underproof strength : subtract the percentage underproof from 100, thus :

Sp. gr. 0.9615 = 42.00 per cent. u.p. and contains $100 - 42 = 58$ per cent. of proof spirit.

American proof spirit is defined as containing one half of its volume of Tralles's alcohol at 15.6° C. The latter has the sp. gr. 0.7946 at 15.6°/15.6° C. But as the American gallon is only $\frac{3}{4}$ ths of the British gallon, 100 British proof gallons are equal to 137 American proof gallons.

* For the full table, proceeding by 0.0002 sp. gr., see *Alcoholometric Tables*, by Sir E. Thorpe (Longmans, Green & Co.).

ALCOHOLIMETRIC TABLE

Sp. gr. at 60 F., 60 F.	Percentage of alcohol		Per cent over proof	Sp. gr. at 60 F., 60 F.	Percentage of alcohol		Per cent over proof
	By weight	By volume			By weight	By volume	
0.79359	100.00	100.00	75.35	0.8115	92.90	93.35	67.19
7940	99.87	99.92	75.21	8150	92.72	93.22	66.96
7945	99.71	99.82	75.04	8155	92.54	93.10	66.73
7950	99.55	99.72	74.87	8160	92.36	92.97	66.51
7955	99.39	99.62	74.70	8165	92.18	92.84	66.29
7960	99.22	99.52	74.52	8170	92.00	92.71	66.06
7965	99.06	99.42	74.34	8175	91.82	92.58	65.83
7970	98.90	99.32	74.16	8180	91.63	92.45	65.60
7975	98.74	99.22	73.98	8185	91.45	92.32	65.37
7980	98.57	99.12	73.80	8190	91.27	92.19	65.14
7985	98.41	99.02	73.62	8195	91.08	92.06	64.91
7990	98.24	98.91	73.44	8200	90.90	91.92	64.67
7995	98.08	98.81	73.26	8205	90.71	91.79	64.44
8000	97.91	98.70	73.07	8210	90.53	91.65	64.20
8005	97.75	98.60	72.89	8215	90.35	91.52	63.96
8010	97.59	98.49	72.71	8220	90.16	91.38	63.72
8015	97.42	98.39	72.52	8225	89.97	91.25	63.48
8020	97.25	98.28	72.34	8230	89.79	91.11	63.24
8025	97.08	98.17	72.14	8235	89.60	90.97	63.00
8030	96.91	98.06	71.95	8240	89.41	90.83	62.75
8035	96.74	97.95	71.76	8245	89.22	90.69	62.51
8040	96.57	97.84	71.56	8250	89.03	90.55	62.26
8045	96.40	97.73	71.37	8255	88.84	90.41	62.01
8050	96.23	97.62	71.17	8260	88.65	90.26	61.76
8055	96.06	97.51	70.97	8265	88.46	90.12	61.51
8060	95.89	97.39	70.77	8270	88.27	90.00	61.26
8065	95.72	97.28	70.57	8275	88.08	90.84	61.01
8070	95.55	97.16	70.37	8280	87.88	90.71	60.75
8075	95.38	97.05	70.17	8285	87.69	90.55	60.50
8080	95.20	96.93	69.96	8290	87.50	90.40	60.24
8085	95.03	96.81	69.76	8295	87.31	90.26	59.99
8090	94.85	96.69	69.55	8300	87.11	90.11	59.73
8095	94.68	96.57	69.34	8305	86.92	90.00	59.47
8100	94.50	96.45	69.13	8310	86.73	90.82	59.21
8105	94.33	96.33	68.93	8315	86.54	90.67	58.95
8110	94.15	96.21	68.71	8320	86.34	90.52	58.69
8115	93.98	96.09	68.50	8325	86.15	90.37	58.43
8120	93.80	95.97	68.28	8330	85.95	90.22	58.16
8125	93.62	95.85	68.07	8335	85.76	90.07	57.90
8130	93.44	95.72	67.86	8340	85.56	89.91	57.63
8135	93.26	95.60	67.64	8345	85.37	89.76	57.37
8140	93.08	95.47	67.41	8350	85.17	89.61	57.10

ALCOHOLOMETRIC TABLE *continued.*

Sp. gr. at 60 F., 60 F.	Percentage of alcohol		Per cent. over proof.	Sp. gr. at 60 F., 60 F.	Percentage of alcohol		Per cent. over proof.
	By weight.	By volume.			By weight.	By volume.	
0.8355	84.98	89.46	56.53	0.8565	76.51	82.56	44.71
0.8360	81.78	89.50	56.56	0.8570	76.50	82.38	44.40
0.8365	84.59	89.15	56.29	0.8575	76.09	82.21	44.09
0.8370	81.39	88.90	56.02	0.8580	75.88	82.03	43.78
0.8375	81.19	88.84	55.75	0.8585	75.68	81.86	43.47
0.8380	83.99	88.68	55.47	0.8590	75.47	81.68	43.16
0.8385	83.80	88.52	55.20	0.8595	75.26	81.50	42.85
0.8390	83.60	88.37	54.92	0.8600	75.05	81.32	42.54
0.8395	83.40	88.22	54.65	0.8605	74.85	81.15	42.23
0.8400	83.20	88.06	54.37	0.8610	74.64	80.97	41.91
0.8405	83.00	87.90	54.10	0.8615	74.43	80.79	41.60
0.8410	82.80	87.74	53.81	0.8620	74.22	80.61	41.28
0.8415	82.60	87.58	53.53	0.8625	74.02	80.43	40.97
0.8420	82.40	87.42	53.25	0.8630	73.81	80.25	40.65
0.8425	82.20	87.25	52.97	0.8635	73.60	80.07	40.34
0.8430	82.00	87.09	52.68	0.8640	73.39	79.89	40.02
0.8435	81.80	86.93	52.40	0.8645	73.18	79.71	39.70
0.8440	81.60	86.77	52.12	0.8650	72.97	79.53	39.38
0.8445	81.40	86.61	51.84	0.8655	72.76	79.35	39.06
0.8450	81.20	86.44	51.55	0.8660	72.55	79.16	38.74
0.8455	81.00	86.28	51.26	0.8665	72.35	78.98	38.42
0.8460	80.79	86.12	50.97	0.8670	72.14	78.80	38.10
0.8465	80.59	85.96	50.68	0.8675	71.93	78.62	37.78
0.8470	80.39	85.80	50.39	0.8680	71.72	78.43	37.46
0.8475	80.19	85.63	50.10	0.8685	71.51	78.25	37.14
0.8480	79.98	85.46	49.80	0.8690	71.30	78.06	36.81
0.8485	79.78	85.29	49.51	0.8695	71.09	77.88	36.49
0.8490	79.58	85.12	49.21	0.8700	70.88	77.69	36.16
0.8495	79.38	84.95	48.92	0.8705	70.67	77.51	35.83
0.8500	79.17	84.78	48.62	0.8710	70.46	77.32	35.50
0.8505	78.97	84.61	48.33	0.8715	70.25	77.13	35.17
0.8510	78.76	84.44	48.03	0.8720	70.04	76.94	34.84
0.8515	78.56	84.28	47.73	0.8725	69.83	76.75	34.52
0.8520	78.35	84.11	47.43	0.8730	69.62	76.57	34.19
0.8525	78.15	83.94	47.13	0.8735	69.41	76.38	33.86
0.8530	77.94	83.77	46.83	0.8740	69.19	76.19	33.53
0.8535	77.74	83.60	46.53	0.8745	68.98	76.01	33.20
0.8540	77.53	83.42	46.23	0.8750	68.77	75.82	32.86
0.8545	77.33	83.25	45.93	0.8755	68.56	75.63	32.53
0.8550	77.12	83.08	45.62	0.8760	68.35	75.44	32.19
0.8555	76.92	82.91	45.32	0.8765	68.14	75.25	31.86
0.8560	76.71	82.73	45.01	0.8770	67.93	75.06	31.53

ALCOHOLOMETRIC TABLE *continued.*

Sp. gr. at 60° F./60° F.	Percentage of alcohol.		Per- cent. over proof	Sp. gr. at 60° F./60° F.	Per- cent. over proof	Percentage of alcohol.		Per- cent. over proof.
	By weight.	By volume.				By weight.	By volume.	
8775	67.73	71.87	31.29	8990	58.59	66.25	16.07	
8780	67.51	71.68	30.86	8995	58.28	66.01	15.80	
8785	67.30	71.49	30.52	9000	58.06	65.83	15.53	
8790	67.09	71.30	30.18	9005	57.84	65.65	15.26	
8795	66.88	71.11	29.84	9010	57.62	65.47	14.99	
8800	66.66	70.92	29.50	9015	57.40	65.29	14.72	
8805	66.45	70.73	29.15	9020	57.18	65.10	14.45	
8810	66.24	70.54	28.82	9025	56.97	64.92	14.18	
8815	66.03	70.35	28.48	9030	56.75	64.73	13.91	
8820	65.81	70.16	28.15	9035	56.53	64.55	13.64	
8825	65.60	70.00	27.80	9040	56.31	64.36	13.37	
8830	65.39	69.74	27.45	9045	56.09	64.17	13.10	
8835	65.18	69.54	27.10	9050	55.87	63.98	12.83	
8840	64.96	69.35	26.75	9055	55.65	63.79	12.56	
8845	64.75	69.16	26.42	9060	55.42	63.60	12.29	
8850	64.53	68.96	26.07	9065	55.20	63.41	12.02	
8855	64.32	68.77	25.72	9070	54.98	63.22	11.75	
8860	64.10	68.58	25.38	9075	54.76	63.03	11.48	
8865	63.89	68.39	25.02	9080	54.54	62.84	11.21	
8870	63.67	68.20	24.67	9085	54.32	62.65	10.94	
8875	63.46	68.00	24.32	9090	54.10	62.46	10.67	
8880	63.24	67.81	23.97	9095	53.88	62.27	10.40	
8885	63.03	67.62	23.62	9100	53.65	62.08	10.13	
8890	62.81	67.43	23.27	9105	53.43	61.89	9.86	
8895	62.60	67.24	22.92	9110	53.21	61.70	9.59	
8900	62.38	67.05	22.56	9115	52.99	61.51	9.32	
8905	62.17	66.86	22.21	9120	52.77	61.32	9.05	
8910	61.95	66.67	21.85	9125	52.55	61.13	8.78	
8915	61.74	66.48	21.50	9130	52.33	60.94	8.51	
8920	61.52	66.29	21.14	9135	52.11	60.75	8.24	
8925	61.31	66.10	20.78	9140	51.89	60.56	7.97	
8930	61.09	65.91	20.42	9145	51.67	60.37	7.70	
8935	60.88	65.72	20.06	9150	51.45	60.18	7.43	
8940	60.66	65.53	19.70	9155	51.23	59.99	7.16	
8945	60.45	65.34	19.34	9160	51.01	59.80	6.89	
8950	60.23	65.15	18.98	9165	50.79	59.61	6.62	
8955	60.02	64.96	18.62	9170	50.57	59.42	6.35	
8960	59.80	64.77	18.26	9175	50.35	59.23	6.08	
8965	59.59	64.58	17.90	9180	50.13	59.04	5.81	
8970	59.37	64.39	17.54	9185	49.91	58.85	5.54	
8975	59.15	64.20	17.18	9190	49.69	58.66	5.27	
8980	58.93	64.01	16.81	9195	49.47	58.47	5.00	
8985	58.72	63.82	16.44	9196	49.28	58.28	4.73	

ALCOHOLOMETRIC TABLE - continued

Sp. gr. at 60° F., or F.	Percentage of alcohol.		Per cent under proof.	Sp. gr. at 60° F., or F.	Percentage of alcohol.		Per cent under proof.
	By weight.	By volume.			By weight.	By volume.	
0.9200	49.17	56.99	0.20	0.9410	39.15	46.40	18.77
0.9205	48.94	56.76	0.61	0.9415	38.90	46.13	19.26
0.9210	48.71	56.52	1.02	0.9420	38.61	45.85	19.74
0.9215	48.48	56.29	1.44	0.9425	38.38	45.57	20.24
0.9220	48.25	56.05	1.84	0.9430	38.12	45.28	20.74
0.9225	48.02	55.82	2.25	0.9435	37.86	45.00	21.24
0.9230	47.79	55.58	2.67	0.9440	37.60	44.71	21.71
0.9235	47.56	55.34	3.09	0.9445	37.34	44.42	22.25
0.9240	47.33	55.10	3.51	0.9450	37.07	44.13	22.76
0.9245	47.10	54.86	3.93	0.9455	36.81	43.84	23.28
0.9250	46.87	54.62	4.35	0.9460	36.54	43.54	23.79
0.9255	46.64	54.38	4.77	0.9465	36.27	43.25	24.31
0.9260	46.40	54.14	5.20	0.9470	36.00	42.95	24.83
0.9265	46.17	53.90	5.63	0.9475	35.73	42.65	25.36
0.9270	45.94	53.65	6.05	0.9480	35.46	42.35	25.88
0.9275	45.71	53.41	6.48	0.9485	35.19	42.05	26.42
0.9280	45.47	53.16	6.91	0.9490	34.92	41.74	26.95
0.9285	45.24	52.92	7.34	0.9495	34.65	41.44	27.49
0.9290	45.00	52.67	7.77	0.9500	34.37	41.13	28.02
0.9295	44.77	52.43	8.21	0.9505	34.09	40.82	28.58
0.9300	44.53	52.18	8.64	0.9510	33.81	40.50	29.13
0.9305	44.29	51.93	9.08	0.9515	33.53	40.19	29.69
0.9310	44.06	51.68	9.51	0.9520	33.25	39.87	30.24
0.9315	43.83	51.43	9.95	0.9525	32.96	39.55	30.81
0.9320	43.59	51.18	10.39	0.9530	32.67	39.22	31.38
0.9325	43.35	50.93	10.81	0.9535	32.38	38.90	31.95
0.9330	43.11	50.67	11.29	0.9540	32.09	38.57	32.52
0.9335	42.87	50.41	11.74	0.9545	31.80	38.23	33.12
0.9340	42.62	50.15	12.19	0.9550	31.50	37.89	33.71
0.9345	42.38	49.89	12.65	0.9555	31.20	37.55	34.31
0.9350	42.13	49.63	13.11	0.9560	30.90	37.20	34.91
0.9355	41.89	49.37	13.57	0.9565	30.59	36.85	35.53
0.9360	41.64	49.10	14.03	0.9570	30.28	36.50	36.15
0.9365	41.40	48.84	14.50	0.9575	29.97	36.15	36.78
0.9370	41.15	48.57	14.96	0.9580	29.66	35.79	37.40
0.9375	40.90	48.31	15.43	0.9585	29.35	35.43	38.04
0.9380	40.65	48.04	15.90	0.9590	29.03	35.06	38.68
0.9385	40.40	47.77	16.38	0.9595	28.71	34.70	39.33
0.9390	40.15	47.50	16.85	0.9600	28.39	34.33	39.97
0.9395	39.90	47.23	17.33	0.9605	28.06	33.95	40.65
0.9400	39.65	46.95	17.81	0.9610	27.73	33.56	41.32
0.9405	39.40	46.68	18.29	0.9615	27.40	33.18	42.00

ALCOHOLOMETRIC TABLE - continued.

Sp. gr. at 60 F. 60 F.	Percentage of alcohol		Per cent under proof.	Sp. gr. at 60 F. 60 F.	Percentage of alcohol		Per cent under proof.
	By weight	By volume			By weight	By volume	
0.9620	27.66	32.79	42.97	0.9810	19.29	23.08	73.68
0.965	26.72	32.39	43.57	0.9815	19.31	23.11	74.01
0.9650	26.57	32.28	43.67	0.9820	19.32	23.13	74.34
0.9655	26.43	32.16	43.78	0.9825	19.34	23.17	74.66
0.9660	26.28	32.05	43.89	0.9830	19.35	23.20	74.98
0.9665	26.13	31.93	44.00	0.9835	19.37	23.24	75.30
0.9670	25.97	31.81	44.11	0.9840	19.38	23.27	75.62
0.9675	25.82	31.69	44.22	0.9845	19.39	23.29	75.94
0.9680	25.67	31.57	44.33	0.9850	19.40	23.31	76.26
0.9685	25.52	31.45	44.44	0.9855	19.41	23.33	76.58
0.9690	25.37	31.33	44.55	0.9860	19.42	23.35	76.90
0.9695	25.22	31.21	44.66	0.9865	19.43	23.37	77.22
0.9700	25.07	31.09	44.77	0.9870	19.44	23.39	77.54
0.9705	24.92	30.97	44.88	0.9875	19.45	23.41	77.86
0.9710	24.77	30.85	44.99	0.9880	19.46	23.43	78.18
0.9715	24.62	30.73	45.10	0.9885	19.47	23.45	78.50
0.9720	24.47	30.61	45.21	0.9890	19.48	23.47	78.82
0.9725	24.32	30.49	45.32	0.9895	19.49	23.49	79.14
0.9730	24.17	30.37	45.43	0.9900	19.50	23.51	79.46
0.9735	24.02	30.25	45.54	0.9905	19.51	23.53	79.78
0.9740	23.87	30.13	45.65	0.9910	19.52	23.55	80.10
0.9745	23.72	30.01	45.76	0.9915	19.53	23.57	80.42
0.9750	23.57	29.89	45.87	0.9920	19.54	23.59	80.74
0.9755	23.42	29.77	45.98	0.9925	19.55	23.61	81.06
0.9760	23.27	29.65	46.09	0.9930	19.56	23.63	81.38
0.9765	23.12	29.53	46.20	0.9935	19.57	23.65	81.70
0.9770	22.97	29.41	46.31	0.9940	19.58	23.67	82.02
0.9775	22.82	29.29	46.42	0.9945	19.59	23.69	82.34
0.9780	22.67	29.17	46.53	0.9950	19.60	23.71	82.66
0.9785	22.52	29.05	46.64	0.9955	19.61	23.73	82.98
0.9790	22.37	28.93	46.75	0.9960	19.62	23.75	83.30
0.9795	22.22	28.81	46.86	0.9965	19.63	23.77	83.62
0.9800	22.07	28.69	46.97	0.9970	19.64	23.79	83.94
0.9805	21.92	28.57	47.08	0.9975	19.65	23.81	84.26
0.9810	21.77	28.45	47.19	0.9980	19.66	23.83	84.58
0.9815	21.62	28.33	47.30	0.9985	19.67	23.85	84.90
0.9820	21.47	28.21	47.41	0.9990	19.68	23.87	85.22
0.9825	21.32	28.09	47.52	0.9995	19.69	23.89	85.54
0.9830	21.17	27.97	47.63	1.0000	19.70	23.91	85.86
0.9835	21.02	27.85	47.74				
0.9840	20.87	27.73	47.85				
0.9845	20.72	27.61	47.96				
0.9850	20.57	27.49	48.07				
0.9855	20.42	27.37	48.18				
0.9860	20.27	27.25	48.29				
0.9865	20.12	27.13	48.40				
0.9870	19.97	27.01	48.51				
0.9875	19.82	26.89	48.62				
0.9880	19.67	26.77	48.73				
0.9885	19.52	26.65	48.84				
0.9890	19.37	26.53	48.95				
0.9895	19.22	26.41	49.06				
0.9900	19.07	26.29	49.17				
0.9905	18.92	26.17	49.28				
0.9910	18.77	26.05	49.39				
0.9915	18.62	25.93	49.50				
0.9920	18.47	25.81	49.61				
0.9925	18.32	25.69	49.72				
0.9930	18.17	25.57	49.83				
0.9935	18.02	25.45	49.94				
0.9940	17.87	25.33	50.05				
0.9945	17.72	25.21	50.16				
0.9950	17.57	25.09	50.27				
0.9955	17.42	24.97	50.38				
0.9960	17.27	24.85	50.49				
0.9965	17.12	24.73	50.60				
0.9970	16.97	24.61	50.71				
0.9975	16.82	24.49	50.82				
0.9980	16.67	24.37	50.93				
0.9985	16.52	24.25	51.04				
0.9990	16.37	24.13	51.15				
0.9995	16.22	24.01	51.26				
1.0000	16.07	23.89	51.37				

FORMULÆ FOR THE CONVERSION OF DIFFERENT STATEMENTS,
OF ALCOHOLIC STRENGTH.

Let S = sp. gr. at 60° F./ 60° F.
 $\frac{w}{v}$ = grams of absolute alcohol per 100 grams.
 $\frac{r}{v}$ = c.c. " " " " 100 c.c.
 $\frac{w}{p}$ = grams " " " " 100 c.c.
 P = c.c. of proof spirit per 100 c.c.

And using v to indicate the volume occupied by 1 gram of water at 60° F. ("reputed" c.c.).

$$\begin{aligned}\text{Then } \frac{w}{v} &= 0.7936 \frac{r}{v} - \frac{w}{p} \frac{r}{v} = 0.45326 \frac{P}{S} \\ \frac{r}{v} &= \frac{w}{v} \times 1.2601 \frac{S}{S} - 1.2601 \frac{w}{p} \frac{r}{v} = 0.5710 \frac{P}{S} \\ \frac{w}{p} &= \frac{w}{v} \times S - 0.7936 \frac{r}{v} = 0.45326 \frac{P}{S} \\ P &= \frac{w}{v} \times 2.2063 \frac{S}{S} - 1.751 \frac{r}{v} = 2.2063 \frac{r}{v}.\end{aligned}$$

The methods of obtaining the above formulæ are illustrated by the two examples given below.

To find a formula to convert *percentage by volume* (r/v) into *percentage by weight* (w/v).

100 c.c. of alcohol whose sp. gr. at 60° F. is S weigh 100 S grams and contain r c.c. of absolute alcohol.

That is, 100 S grams contain r c.c. of absolute alcohol.

$$\therefore, 100 \text{ grams} \quad \text{contain} \quad \frac{r}{S} \text{ c.c.} \quad \text{"} \quad \text{"}$$

But 1 c.c. of absolute alcohol weighs 0.7936 gram.

$$\therefore, \frac{r}{S} \text{ c.c. weigh } \frac{r}{S} \times 0.7936 \text{ grams.}$$

That is, 100 grams contain $\frac{r}{S} \times 0.7936$ grams of absolute alcohol,

$$\text{or } \frac{w}{v} = \frac{r}{S} \times 0.7936.$$

Similarly, to find the factor in the case of proof spirit.

Here 100 c.c. contain P c.c. of proof spirit—that is, 100 S grams contain P c.c. of proof spirit.

But 1 c.c. of proof spirit weighs 0.91976 gram and 1 gram of proof spirit contains 0.45326 gram of absolute alcohol.

\therefore , 1 c.c. of proof spirit contains $0.91976 \times 0.45326 = 0.45326$ grams of absolute alcohol.

Therefore 100 S grams of the given alcohol contain $0.45326 \times P$ grams of absolute alcohol.

That is, 100 grams contain $\frac{0.45326 P}{S}$ grams of absolute alcohol

$$\text{or } \% = \frac{0.45326 P}{S}.$$

CORRECTION OF SPECIFIC GRAVITY OF DILUTE ALCOHOL FOR TEMPERATURE.

Specific Gravity.	1° Fah.	1° C.	Specific Gravity.	1° Fah.	1° C.
.794-.851	0.0001	0.000 2	.965-.966	0.0002	0.00017
.864-.889	15	1	.966-.967	15	45
.889-.902	44	7.9	.967-.968	24	43
.902-.912	43	7.7	.968-.969	25	41
.912-.921	42	7.6	.969-.970	22	40
.921-.928	41	7.3	.970-.971	31	38
.928-.935	40	7.2	.971-.973	20	36
.935-.940	39	7	.973-.974	19	34
.940-.943	38	68	.974-.975	18	32
.943-.946	37	67	.975-.976	17	31
.946-.949	36	65	.976-.977	16	29
.949-.951	35	63	.977-.978	15	27
.951-.953	34	61	.978-.980	14	25
.953-.955	33	59	.981-.981	13	23
.955-.957	32	58	.981-.983	12	22
.957-.959	31	56	.983-.985	11	20
.959-.961	30	54	.985-.987	10	18
.961-.962	29	52	.987-.990	0099	16
.962-.963	28	50	.990-.995	7	14
.963-.965	27	49	.995-1.000	7	13

Rule.—To obtain correct sp. gr. at 60° Fah. (15.5° C.), multiply the factor given in the table opposite to the observed sp. gr. by the difference in temperature, and *add* if the recorded temperature is *above* 60° F., or *subtract* if it is *below* 60°.

Ex.—The sp. gr. at 60° Fah. of dilute alcohol of sp. gr. 0.952 at 64° Fah. is 0.9524 (0.00031 × 4) 0.95236.

RULES FOR DILUTION OF ALCOHOL.

Find in every case what fraction of strength the weaker spirit is of the stronger in terms of proof spirit, and thence obtain the quantity of the stronger spirit to be diluted to produce the required amount of the weaker spirit.

Ex. 1. To make 20 gallons of spirit 20 u.p. from spirit 25 u.p.

Spirit 20 u.p. contains 80 per cent. of pr. of spirit.

25" u.p. " 125 " " "

Hence the fraction is $\frac{80}{125} = \frac{16}{25}$, and the amount of the stronger

spirit required is $\frac{16}{25} \times 20 = 12.8$ gallons, or 12 gallons 3 quarts 8 fl. ounces. This is carefully diluted with water till the mixture measures 20 gallons.

(80 vols. of the above strong spirit diluted to 125 vols. will give spirit 20° u.p.)

Ex. 2. To make 20 gallons of spirit 30° o.p. from spirit 60° o.p.

Here the fraction is $\frac{130}{160} = \frac{13}{16}$, and $\frac{13}{16} \times 20 = 16\frac{1}{4}$.

Hence 16 $\frac{1}{4}$ gallons, or 16 gallons 1 quart of the stronger spirit must be diluted to 20 gallons.

(130 vols. of the stronger spirit diluted to 160 vols. will give spirit 30° o.p.)

Approximations.—In technical operations it is frequently required to know what proportion of water must be added to spirit in order to reduce its strength by a given amount. In this case the contraction that takes place when spirit and water are mixed is disregarded, and the calculation is based on the principle that the volume is inversely as the strength. The volume which the reduced spirit will have is calculated, and the difference between this and the original volume is taken as the volume of (distilled) water to be added.

Ex. How much water is required to reduce 60 gallons of spirit at 10° o.p. to 5° o.p.?

10° o.p. = 110 per cent. of proof spirit.

5° o.p. = 105°

Hence volume of reduced spirit will be,

$$60 \times \frac{110}{105} = 62.9 \text{ gallons.}$$

and the volume of water to be added is 62.9 - 60 = 2.9 gallons.

Distillation of Spirits.—In determining spirit strengths by distillation it should be noted that, while it is possible to distil without loss spirits of underproof strength into the same volume, it is necessary to dilute overproof spirits and distil into two, three, or four times the original volume.

The strength of spirits can also be determined by boiling off the alcohol, etc. (Tabarie's method). For details and Blunt's improved formula for calculating results, see p. 105.

Obscuration. The amount by which the true alcoholic strength of brandy or rum differs from the apparent strength as indicated by a hydrometer or a density determination is termed the "obscuration."

In "The Sale of Food and Drugs Act Amendment Act, 1879," section 6, it is enacted that Brandy, Whisky, or Rum may be reduced to 25° u.p. and Gin to 35° u.p.

This, however, has been superseded, and at the present time (1920) no spirits are allowed to be sold at a higher strength than 30° u.p.

The following example will show how to calculate percentages of added water in diluted spirits.

Suppose 25° u.p. is allowed.

If a sample is N° u.p., 100 volumes will contain N volumes of water and (100 - N) volumes of proof spirit.

Let x be the percentage of water by volume added to spirit of 25° u.p. to produce a sample N° u.p.

Then, equating amounts of water, we have

$$\begin{aligned} (100 - x) \frac{25}{100} + x - N, \\ 25 \frac{x}{4} + x - N, \\ \frac{5}{4} x - N = 25, \\ x = \frac{4}{3}(N - 25) \end{aligned}$$

Hence, to get added water increase the excess of degrees n.p. above 25 by one-third.

Similarly, if 30 n.p. are allowed, the formula becomes

$$x_1 = \frac{10}{3}(N - 30),$$

and if 35° n.p. are allowed,

$$x_2 = \frac{20}{13}(N - 35) = 1.54(N - 35).$$

TABLE SHOWING THE AMOUNTS TO BE *subtracted* FROM THE VALUES GIVEN IN THE PHOSPHATE TABLE SO THAT THEY MAY BE IN ACCORDANCE WITH THE INTERNATIONAL ATOMIC WEIGHTS OF 1921.

Mg ₃ P ₂ O ₈	Ca ₃ P ₂ O ₈	CaP ₂ O ₆	PO ₄	
10.0	0.03	0.02	0.02	
15.0	0.05	0.03	0.03	0.008
20.0	0.07	0.05	0.03	0.011
25.0	0.08	0.06	0.04	0.013
30.0	0.09	0.07	0.05	0.016
35.0	0.11	0.08	0.06	0.019
40.0	0.13	0.09	0.07	0.021
45.0	0.15	0.10	0.07	0.025
50.0	0.16	0.12	0.08	0.027
55.0	0.18	0.13	0.09	0.029
60.0	0.19	0.13	0.10	0.033
65.0	0.21	0.14	0.11	0.035
70.0	0.23	0.15	0.12	0.038

Ex. 2 grams of a sample of Superphosphate gave 0.3770 gram Mg₂P₂O₇.

From the table 37.70

Correction (mean of .11 and .13)

= 52.61 Ca₃P₂O₈

.12

2)52.52

26.26 Ca₃P₂O₈

TABLE FOR PHOSPHATES.

$\text{Mg}_2\text{P}_2\text{O}_7$	$\text{Ca}_3\text{P}_2\text{O}_8$	CaP_2O_6	P_2O_5	P_2	$\text{Mg}_2\text{P}_2\text{O}_7$	$\text{Ca}_3\text{P}_2\text{O}_8$	CaP_2O_6	P_2O_5	P_2
0.1	0.14	0.09	0.06	0.028	4.1	5.73	3.66	2.62	1.145
0.2	0.28	0.18	0.13	0.056	4.2	5.87	3.75	2.69	1.173
0.3	0.42	0.27	0.19	0.084	4.3	6.00	3.84	2.75	1.201
0.4	0.56	0.36	0.26	0.112	4.4	6.14	3.93	2.82	1.229
0.5	0.70	0.45	0.32	0.140	4.5	6.28	4.01	2.88	1.257
0.6	0.84	0.54	0.38	0.168	4.6	6.42	4.10	2.94	1.285
0.7	0.98	0.62	0.45	0.196	4.7	6.56	4.19	3.01	1.313
0.8	1.12	0.71	0.51	0.224	4.8	6.70	4.28	3.07	1.341
0.9	1.26	0.80	0.58	0.251	4.9	6.84	4.37	3.14	1.369
1.0	1.40	0.89	0.64	0.279	5.0	6.98	4.46	3.20	1.396
1.1	1.54	0.98	0.70	0.307	5.1	7.12	4.55	3.26	1.424
1.2	1.68	1.07	0.77	0.335	5.2	7.26	4.64	3.33	1.452
1.3	1.82	1.16	0.83	0.363	5.3	7.40	4.73	3.39	1.480
1.4	1.96	1.25	0.90	0.391	5.4	7.54	4.82	3.45	1.508
1.5	2.09	1.34	0.96	0.419	5.5	7.68	4.91	3.52	1.536
1.6	2.23	1.43	1.02	0.447	5.6	7.82	5.00	3.58	1.564
1.7	2.37	1.52	1.09	0.475	5.7	7.96	5.08	3.65	1.592
1.8	2.51	1.61	1.15	0.503	5.8	8.10	5.17	3.71	1.620
1.9	2.65	1.70	1.22	0.531	5.9	8.24	5.26	3.77	1.648
2.0	2.79	1.78	1.28	0.559	6.0	8.38	5.35	3.84	1.676
2.1	2.93	1.87	1.34	0.587	6.1	8.52	5.44	3.90	1.704
2.2	3.07	1.96	1.41	0.614	6.2	8.66	5.53	3.97	1.732
2.3	3.21	2.05	1.47	0.642	6.3	8.80	5.62	4.03	1.760
2.4	3.35	2.14	1.54	0.670	6.4	8.94	5.71	4.09	1.787
2.5	3.49	2.23	1.60	0.698	6.5	9.08	5.80	4.16	1.815
2.6	3.63	2.32	1.66	0.726	6.6	9.22	5.89	4.22	1.843
2.7	3.77	2.41	1.73	0.754	6.7	9.36	5.98	4.29	1.871
2.8	3.91	2.50	1.79	0.782	6.8	9.50	6.07	4.35	1.899
2.9	4.05	2.59	1.86	0.810	6.9	9.64	6.15	4.41	1.927
3.0	4.19	2.68	1.92	0.838	7.0	9.77	6.24	4.48	1.955
3.1	4.33	2.77	1.98	0.866	7.1	9.91	6.33	4.54	1.983
3.2	4.47	2.85	2.05	0.894	7.2	10.05	6.42	4.61	2.011
3.3	4.61	2.94	2.11	0.922	7.3	10.19	6.51	4.67	2.039
3.4	4.75	3.03	2.18	0.950	7.4	10.33	6.60	4.73	2.067
3.5	4.89	3.12	2.24	0.978	7.5	10.47	6.69	4.80	2.095
3.6	5.03	3.21	2.30	1.006	7.6	10.61	6.78	4.86	2.123
3.7	5.17	3.30	2.37	1.033	7.7	10.75	6.87	4.93	2.151
3.8	5.31	3.39	2.43	1.061	7.8	10.89	6.96	4.99	2.178
3.9	5.45	3.48	2.50	1.089	7.9	11.03	7.05	5.05	2.206
4.0	5.59	3.57	2.56	1.117	8.0	11.17	7.14	5.12	2.234
$\text{Mg}_2\text{P}_2\text{O}_7$	.01	.02	.03	.04	.05	.06	.07	.08	.09
$\text{Ca}_3\text{P}_2\text{O}_8$	.01	.03	.04	.06	.07	.08	.10	.11	.13
CaP_2O_6	.01	.02	.03	.04	.05	.05	.06	.07	.08
P_2O_5	.01	.01	.02	.03	.03	.04	.05	.05	.06
P_2	.003	.006	.008	.011	.014	.017	.020	.022	.025

TABLE FOR PHOSPHATES—continued

Mg ₂ P ₂ O ₇	Ca ₃ P ₂ O ₈	Ca ₂ P ₂ O ₇	P ₂ O ₅	P	Mg ₂ P ₂ O ₇	Ca ₃ P ₂ O ₈	Ca ₂ P ₂ O ₇	P ₂ O ₅	P
8.1	11.31	7.22	5.48	2.29	12.7	17.13	11.35	8.42	3.34
8.2	11.45	7.31	5.55	2.296	8	17.87	11.42	8.49	3.37
8.3	11.59	7.40	5.61	2.308	9	18.01	11.51	8.55	3.40
8.4	11.72	7.49	5.67	2.314	10	18.15	11.60	8.62	3.43
8.5	11.87	7.58	5.74	2.321	11	18.29	11.68	8.68	3.45
8.6	12.01	7.67	5.80	2.327	12	18.43	11.77	8.74	3.48
8.7	12.15	7.76	5.87	2.333	13	18.57	11.86	8.81	3.51
8.8	12.29	7.85	5.93	2.339	14	18.71	11.95	8.87	3.54
8.9	12.43	7.94	5.99	2.346	15	18.85	12.04	8.94	3.57
9.0	12.57	8.03	6.06	2.351	16	18.99	12.13	9.00	3.59
9.1	12.71	8.12	6.12	2.357	17	19.13	12.22	9.06	3.62
9.2	12.85	8.21	6.19	2.363	18	19.27	12.31	9.13	3.65
9.3	12.99	8.30	6.25	2.369	19	19.41	12.40	9.19	3.68
9.4	13.13	8.38	6.31	2.375	20	19.55	12.49	9.26	3.71
9.5	13.27	8.47	6.38	2.381	21	19.69	12.58	9.32	3.74
9.6	13.41	8.56	6.44	2.387	22	19.83	12.67	9.38	3.77
9.7	13.55	8.65	6.51	2.393	23	19.97	12.76	9.45	3.80
9.8	13.69	8.74	6.57	2.399	24	20.11	12.85	9.51	3.83
9.9	13.83	8.83	6.64	2.405	25	20.25	12.94	9.58	3.86
10.0	13.96	8.92	6.70	2.411	26	20.39	13.03	9.64	3.89
10.1	14.10	9.01	6.76	2.417	27	20.53	13.12	9.71	3.92
10.2	14.24	9.10	6.83	2.423	28	20.67	13.21	9.77	3.95
10.3	14.38	9.19	6.89	2.429	29	20.81	13.30	9.84	3.98
10.4	14.52	9.28	6.95	2.435	30	20.95	13.39	9.90	4.01
10.5	14.66	9.37	7.02	2.441	31	21.09	13.48	9.97	4.04
10.6	14.80	9.45	7.08	2.447	32	21.23	13.57	10.03	4.07
10.7	14.94	9.54	7.14	2.453	33	21.37	13.66	10.10	4.10
10.8	15.08	9.63	7.21	2.459	34	21.51	13.75	10.16	4.13
10.9	15.22	9.72	7.27	2.465	35	21.65	13.84	10.23	4.16
11.0	15.36	9.81	7.34	2.471	36	21.79	13.93	10.29	4.19
11.1	15.50	9.90	7.40	2.477	37	21.93	14.02	10.36	4.22
11.2	15.64	9.99	7.46	2.483	38	22.07	14.11	10.42	4.25
11.3	15.78	10.08	7.53	2.489	39	22.21	14.20	10.49	4.28
11.4	15.92	10.17	7.59	2.495	40	22.35	14.29	10.55	4.31
11.5	16.06	10.26	7.66	2.501	41	22.49	14.38	10.62	4.34
11.6	16.20	10.35	7.72	2.507	42	22.63	14.47	10.68	4.37
11.7	16.34	10.44	7.78	2.513	43	22.77	14.56	10.75	4.40
11.8	16.48	10.53	7.85	2.519	44	22.91	14.65	10.81	4.43
11.9	16.62	10.61	7.91	2.525	45	23.05	14.74	10.88	4.46
12.0	16.76	10.70	7.98	2.531	46	23.19	14.83	10.94	4.49
12.1	16.90	10.79	8.04	2.537	47	23.33	14.92	11.01	4.52
12.2	17.04	10.88	8.11	2.543	48	23.47	15.01	11.07	4.55
12.3	17.18	10.97	8.17	2.549	49	23.61	15.10	11.14	4.58
12.4	17.32	11.06	8.24	2.555	50	23.75	15.19	11.20	4.61
12.5	17.46	11.15	8.30	2.561	51	23.89	15.28	11.27	4.64
12.6	17.60	11.24	8.36	2.567	52	24.03	15.37	11.33	4.67

TABLE FOR PHOSPHATES—continued.

	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
17.3	24.16	15.43	11.07	4.892	21.3	29.74	19.00	13.62	5.949	
4	24.30	15.52	11.13	4.860	4	29.88	19.09	13.69	5.977	
5	24.41	15.61	11.19	4.887	5	30.02	19.18	13.75	6.005	
6	24.58	15.70	11.26	4.915	6	30.16	19.27	13.82	6.033	
7	24.72	15.79	11.32	4.943	7	30.30	19.35	13.88	6.060	
8	24.86	15.88	11.39	4.971	8	30.44	19.44	13.94	6.088	
9	25.00	15.97	11.45	4.999	9	30.58	19.53	14.01	6.116	
18.0	25.14	16.05	11.51	5.027	22.0	30.72	19.62	14.07	6.144	
1	25.27	16.14	11.58	5.055	1	30.86	19.71	14.14	6.172	
2	25.41	16.23	11.64	5.083	2	31.00	19.80	14.20	6.200	
3	25.55	16.32	11.71	5.111	3	31.14	19.89	14.26	6.228	
4	25.69	16.41	11.77	5.139	4	31.28	19.98	14.33	6.256	
5	25.83	16.50	11.83	5.167	5	31.42	20.07	14.39	6.284	
6	25.97	16.59	11.90	5.195	6	31.56	20.16	14.46	6.312	
7	26.11	16.68	11.96	5.223	7	31.70	20.25	14.52	6.340	
8	26.25	16.77	12.03	5.250	8	31.84	20.34	14.58	6.368	
9	26.39	16.86	12.09	5.278	9	31.98	20.43	14.65	6.396	
19.0	26.53	16.95	12.15	5.306	23.0	32.12	20.51	14.71	6.423	
1	26.67	17.04	12.22	5.334	1	32.26	20.60	14.78	6.451	
2	26.81	17.12	12.28	5.362	2	32.40	20.69	14.84	6.479	
3	26.95	17.21	12.35	5.390	3	32.54	20.78	14.90	6.507	
4	27.09	17.30	12.41	5.418	4	32.68	20.87	14.97	6.535	
5	27.23	17.39	12.47	5.446	5	32.82	20.96	15.03	6.563	
6	27.37	17.48	12.54	5.474	6	32.96	21.05	15.10	6.591	
7	27.51	17.57	12.60	5.502	7	33.09	21.14	15.16	6.619	
8	27.65	17.66	12.67	5.530	8	33.23	21.23	15.22	6.647	
9	27.79	17.75	12.73	5.558	9	33.37	21.32	15.29	6.675	
20.0	27.93	17.84	12.79	5.586	24.0	33.51	21.41	15.35	6.703	
1	28.07	17.93	12.86	5.614	1	33.65	21.50	15.42	6.731	
2	28.21	18.02	12.92	5.642	2	33.79	21.58	15.48	6.759	
3	28.35	18.11	12.99	5.669	3	33.93	21.67	15.54	6.787	
4	28.49	18.20	13.05	5.697	4	34.07	21.76	15.61	6.814	
5	28.63	18.28	13.11	5.725	5	34.21	21.85	15.67	6.842	
6	28.77	18.37	13.18	5.753	6	34.35	21.94	15.74	6.870	
7	28.91	18.46	13.24	5.781	7	34.49	22.03	15.80	6.898	
8	29.05	18.55	13.31	5.809	8	34.63	22.12	15.86	6.926	
9	29.19	18.64	13.37	5.837	9	34.77	22.21	15.93	6.954	
21.0	29.32	18.73	13.43	5.865	25.0	34.91	22.30	15.99	6.982	
1	29.46	18.82	13.50	5.893	1	35.05	22.39	16.06	7.010	
2	29.60	18.91	13.56	5.921	2	35.19	22.48	16.12	7.038	
	$Mg_2P_2O_7$	.01	.02	.03	.04	.05	.06	.07	.08	.09
	$Ca_3P_2O_8$	.01	.03	.04	.06	.07	.08	.10	.11	.13
	CaP_2O_6	.01	.02	.03	.04	.05	.05	.06	.07	.08
	P_2O_5	.01	.01	.02	.03	.03	.04	.05	.05	.06
	P_2	.003	.006	.008	.011	.014	.017	.020	.022	.025

TABLE FOR PHOSPHATES—continued

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaH_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaH_2O_6	P_2O_5	P_2
25.3	35.33	22.37	16.18	7.066	30.9	41.75	26.07	19.14	8.351
4	35.47	22.66	16.25	7.091	30.0	41.89	26.16	19.19	8.378
6	35.61	22.74	16.31	7.120	1	42.03	26.35	19.25	8.406
6	35.75	22.82	16.38	7.150	2	42.17	26.54	19.32	8.434
7	35.89	22.92	16.44	7.181	3	42.31	26.73	19.38	8.462
8	36.03	23.01	16.50	7.212	4	42.45	26.91	19.45	8.490
9	36.17	23.10	16.57	7.243	5	42.59	27.20	19.51	8.518
26.0	36.31	23.19	16.63	7.274	6	42.73	27.29	19.57	8.546
1	36.45	23.28	16.70	7.305	7	42.87	27.57	19.64	8.574
2	36.59	23.37	16.76	7.337	8	43.01	27.85	19.70	8.602
3	36.73	23.46	16.82	7.368	9	43.15	27.96	19.77	8.630
4	36.87	23.55	16.89	7.399	31.0	43.29	27.95	19.83	8.658
5	37.00	23.61	16.95	7.431	1	43.43	27.74	19.89	8.686
6	37.14	23.72	17.00	7.462	2	43.57	27.83	19.96	8.714
7	37.28	23.81	17.06	7.493	3	43.71	27.92	20.02	8.742
8	37.42	23.90	17.11	7.525	4	43.85	28	20.09	8.769
9	37.56	23.99	17.17	7.556	5	43.99	28.16	20.15	8.797
27.0	37.70	24.08	17.22	7.587	6	44.13	28.18	20.21	8.825
1	37.84	24.17	17.27	7.619	7	44.27	28.27	20	8.853
2	37.98	24.26	17.33	7.650	8	44.41	28.36	20.31	8.881
3	38.12	24.35	17.38	7.681	9	44.55	28.45	20.41	8.909
4	38.26	24.44	17.43	7.712	32.0	44.69	28.51	20.47	8.937
5	38.40	24.53	17.49	7.743	1	44.83	28.60	20.53	8.965
6	38.54	24.62	17.55	7.774	2	44.97	28.72	20.60	8.993
7	38.68	24.71	17.62	7.805	3	45.11	28.81	20.66	9.021
8	38.82	24.80	17.68	7.836	4	45.24	28.90	20.72	9.049
9	38.96	24.88	17.75	7.867	5	45.38	28.99	20.79	9.077
28.0	39.10	24.97	17.81	7.898	6	45.52	29.08	20.85	9.105
1	39.24	25.06	17.87	7.929	7	45.66	29.17	20.92	9.133
2	39.38	25.15	17.94	7.960	8	45.80	29.26	20.98	9.160
3	39.52	25.24	18.00	7.991	9	45.94	29.34	21.04	9.188
4	39.66	25.33	18.07	8.022	33.0	46.08	29.4	21.11	9.216
5	39.80	25.42	18.13	8.053	1	46.22	29.52	21.17	9.244
6	39.94	25.51	18.20	8.084	2	46.36	29.61	21.24	9.272
7	40.08	25.60	18.26	8.115	3	46.50	29.70	21.30	9.300
8	40.22	25.69	18.32	8.146	4	46.64	29.79	21.36	9.328
9	40.36	25.78	18.39	8.177	5	46.78	29.88	21.43	9.356
29.0	40.50	25.87	18.45	8.208	6	46.92	29.97	21.49	9.384
1	40.64	25.95	18.51	8.239	7	47.06	30.06	21.56	9.412
2	40.78	26.04	18.58	8.270	8	47.20	30.15	21.62	9.440
3	40.92	26.13	18.64	8.301	9	47.34	30.24	21.68	9.468
4	41.06	26.22	18.71	8.332	34.0	47.48	30.33	21.75	9.496
5	41.19	26.31	18.77	8.363	1	47.62	30.41	21.81	9.523
6	41.33	26.40	18.83	8.394	2	47.76	30.50	21.88	9.551
7	41.47	26.49	18.90	8.425	3	47.90	30.59	21.94	9.579
8	41.61	26.58	18.96	8.456	4	48.04	30.68	22.00	9.607

TABLE FOR PHOSPHATES *continued*.

$\text{Mg}_2\text{P}_2\text{O}_7$	$\text{Ca}_3\text{P}_2\text{O}_8$	CaP_2O_6	P_2O_5	P_2	$\text{Mg}_2\text{P}_2\text{O}_7$	$\text{Ca}_3\text{P}_2\text{O}_8$	CaP_2O_6	P_2O_5	P_2
34.5	48.18	30.77	22.07	9.635	38.5	53.76	34.31	24.63	10.752
6	48.32	30.86	22.13	9.653	6	53.90	34.43	24.69	10.780
7	48.46	30.95	22.20	9.671	7	54.04	34.52	24.75	10.808
8	48.60	31.01	22.26	9.719	8	54.18	34.61	24.82	10.836
9	48.74	31.13	22.32	9.749	9	54.32	34.70	24.88	10.864
35.0	48.87	31.22	22.39	9.775	39.0	54.46	34.78	24.95	10.892
1	49.01	31.31	22.45	9.803	1	54.60	34.87	25.01	10.920
2	49.15	31.40	22.52	9.831	2	54.74	34.96	25.07	10.948
3	49.29	31.49	22.58	9.859	3	54.88	35.05	25.14	10.976
4	49.43	31.57	22.64	9.887	4	55.02	35.14	25.20	11.004
5	49.57	31.66	22.71	9.914	5	55.16	35.23	25.27	11.032
6	49.71	31.75	22.77	9.942	6	55.30	35.32	25.33	11.060
7	49.85	31.84	22.84	9.970	7	55.44	35.41	25.39	11.087
8	49.99	31.93	22.90	9.998	8	55.58	35.50	25.46	11.115
9	50.13	32.02	22.96	10.026	9	55.72	35.59	25.52	11.143
36.0	50.27	32.11	23.03	10.054	40.0	55.86	35.68	25.59	11.171
1	50.41	32.20	23.09	10.082	1	56.00	35.77	25.65	11.199
2	50.55	32.29	23.16	10.110	2	56.14	35.85	25.71	11.227
3	50.69	32.38	23.22	10.138	3	56.28	35.94	25.78	11.255
4	50.83	32.47	23.28	10.166	4	56.42	36.03	25.84	11.283
5	50.97	32.55	23.35	10.194	5	56.56	36.12	25.91	11.311
6	51.11	32.64	23.41	10.222	6	56.69	36.21	25.97	11.339
7	51.25	32.73	23.48	10.250	7	56.83	36.30	26.03	11.367
8	51.39	32.82	23.54	10.278	8	56.97	36.39	26.10	11.395
9	51.53	32.91	23.61	10.306	9	57.11	36.48	26.16	11.423
37.0	51.67	33.00	23.67	10.333	41.0	57.25	36.57	26.23	11.451
1	51.81	33.09	23.73	10.361	1	57.39	36.66	26.29	11.478
2	51.95	33.18	23.80	10.389	2	57.53	36.75	26.35	11.506
3	52.09	33.27	23.86	10.417	3	57.67	36.84	26.42	11.534
4	52.23	33.36	23.92	10.445	4	57.81	36.93	26.48	11.562
5	52.37	33.45	23.99	10.473	5	57.95	37.01	26.55	11.590
6	52.51	33.54	24.05	10.501	6	58.09	37.10	26.61	11.618
7	52.64	33.62	24.12	10.529	7	58.23	37.19	26.67	11.646
8	52.78	33.71	24.18	10.557	8	58.37	37.28	26.74	11.674
9	52.92	33.80	24.24	10.585	9	58.51	37.37	26.80	11.702
38.0	53.06	33.89	24.31	10.613	42.0	58.65	37.46	26.87	11.730
1	53.20	33.98	24.37	10.641	1	58.79	37.55	26.93	11.758
2	53.34	34.07	24.43	10.669	2	58.93	37.64	26.99	11.786
3	53.48	34.16	24.50	10.696	3	59.07	37.73	27.06	11.814
4	53.62	34.25	24.56	10.724	4	59.21	37.82	27.12	11.842
$\text{Mg}_2\text{P}_2\text{O}_7$	.01	.02	.03	.04	.05	.06	.07	.08	.09
$\text{Ca}_3\text{P}_2\text{O}_8$	.01	.02	.03	.04	.05	.06	.07	.08	.09
CaP_2O_6	.01	.02	.03	.04	.05	.06	.07	.08	.09
P_2O_5	.01	.01	.02	.03	.03	.04	.05	.05	.06
P_2	.003	.006	.008	.011	.014	.017	.020	.022	.025

TABLE FOR PHOSPHATES—continued.

	Mg ₃ P ₂ O ₇	Cu ₃ P ₂ O ₆	CaP ₂ O ₆	P ₂ O ₅	P ₂	Mg ₃ P ₂ O ₇	Cu ₃ P ₂ O ₆	CaP ₂ O ₆	P ₂ O ₅	P ₂
42.5	59.35	37.91	27.19	11.869	37.1	65.77	42.01	30.13	13.154	
6	59.49	38.00	27.25	11.897	2	65.91	42.10	30.19	13.182	
7	59.63	38.08	27.31	11.925	3	66.05	42.19	30.26	13.210	
8	59.77	38.17	27.38	11.953	4	66.19	42.28	30.32	13.238	
9	59.91	38.26	27.44	11.981	5	66.33	42.37	30.38	13.266	
43.0	60.05	38.35	27.51	12.009	6	66.47	42.45	30.45	13.294	
1	60.18	38.44	27.57	12.037	7	66.61	42.54	30.51	13.322	
2	60.32	38.53	27.63	12.065	8	66.75	42.63	30.58	13.350	
3	60.46	38.62	27.70	12.093	9	66.89	42.72	30.64	13.378	
4	60.60	38.71	27.76	12.121	49.0	67.03	42.81	30.70	13.405	
5	60.74	38.80	27.82	12.149	1	67.17	42.90	30.77	13.433	
6	60.88	38.89	27.89	12.177	2	67.31	42.99	30.83	13.461	
7	61.02	38.98	27.95	12.205	3	67.45	43.08	30.90	13.489	
8	61.16	39.07	28.02	12.232	4	67.59	43.17	30.96	13.517	
9	61.30	39.16	28.08	12.260	5	67.73	43.26	31.02	13.545	
44.0	61.44	39.24	28.14	12.288	6	67.87	43.35	31.09	13.573	
1	61.58	39.33	28.21	12.316	7	68.00	43.44	31.15	13.601	
2	61.72	39.42	28.27	12.344	8	68.14	43.53	31.22	13.629	
3	61.86	39.51	28.34	12.372	9	68.28	43.61	31.29	13.657	
4	62.00	39.60	28.40	12.400	49.0	68.42	43.70	31.35	13.685	
5	62.14	39.69	28.46	12.428	1	68.56	43.79	31.41	13.713	
6	62.28	39.78	28.53	12.456	2	68.70	43.88	31.47	13.741	
7	62.42	39.87	28.59	12.484	3	68.84	43.97	31.53	13.769	
8	62.56	39.96	28.66	12.512	4	68.98	44.06	31.60	13.796	
9	62.70	40.05	28.72	12.540	5	69.12	44.15	31.66	13.824	
45.0	62.84	40.14	28.78	12.568	6	69.26	44.24	31.73	13.852	
1	62.98	40.23	28.85	12.596	7	69.40	44.33	31.79	13.880	
2	63.12	40.31	28.91	12.624	8	69.54	44.42	31.85	13.908	
3	63.26	40.40	28.98	12.651	9	69.68	44.51	31.92	13.936	
4	63.40	40.49	29.04	12.679	50.0	69.82	44.60	31.99	13.964	
5	63.54	40.58	29.10	12.707	1	69.96	44.68	32.05	13.992	
6	63.68	40.67	29.17	12.735	2	70.10	44.77	32.11	14.020	
7	63.82	40.76	29.23	12.763	3	70.24	44.85	32.17	14.048	
8	63.96	40.85	29.30	12.791	4	70.38	44.95	32.24	14.076	
9	64.10	40.94	29.36	12.819	5	70.52	45.04	32.30	14.104	
46.0	64.23	41.03	29.42	12.847	6	70.66	45.13	32.37	14.132	
1	64.37	41.12	29.49	12.875	7	70.80	45.22	32.43	14.160	
2	64.51	41.21	29.55	12.903	8	70.94	45.31	32.49	14.187	
3	64.65	41.30	29.62	12.931	9	71.08	45.40	32.56	14.215	
4	64.79	41.38	29.68	12.959	51.0	71.22	45.49	32.62	14.243	
5	64.93	41.47	29.74	12.987	1	71.36	45.58	32.69	14.271	
6	65.07	41.56	29.81	13.015	2	71.50	45.67	32.75	14.299	
7	65.21	41.65	29.87	13.042	3	71.64	45.76	32.81	14.327	
8	65.35	41.74	29.94	13.070	4	71.78	45.85	32.88	14.355	
9	65.49	41.83	30.00	13.098	5	71.91	45.93	32.94	14.383	
47.0	65.63	41.92	30.06	13.126	6	72.05	46.02	33.01	14.411	

TABLE FOR PHOSPHATES—continued.

$Mg_2P_2O_7$	$Ca_2P_2O_6$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_2P_2O_6$	CaP_2O_6	P_2O_5	P_2
51.7	72.19	46.11	33.07	14.439	55.7	77.78	49.68	35.63	15.556
8	72.33	46.20	33.13	14.467	8	77.92	49.77	35.69	15.584
9	72.47	46.29	33.26	14.495	9	78.06	49.86	35.76	15.612
52.0	72.61	46.38	33.26	14.523	56.0	78.20	49.95	35.82	15.640
1	72.75	46.47	33.33	14.551	1	78.34	50.04	35.88	15.668
2	72.89	46.56	33.39	14.579	2	78.48	50.12	35.95	15.696
3	73.03	46.65	33.45	14.606	3	78.62	50.21	36.01	15.721
4	73.17	46.74	33.52	14.634	4	78.76	50.30	36.08	15.751
5	73.31	46.83	33.58	14.662	5	78.90	50.39	36.14	15.779
6	73.45	46.91	33.65	14.690	6	79.04	50.48	36.20	15.807
7	73.59	47.00	33.71	14.714	7	79.18	50.57	36.27	15.835
8	73.73	47.09	33.77	14.746	8	79.32	50.66	36.33	15.863
9	73.87	47.18	33.84	14.774	9	79.46	50.75	36.40	15.891
53.0	74.01	47.27	33.90	14.802	57.0	79.60	50.81	36.46	15.919
1	74.15	47.36	33.97	14.830	1	79.74	50.93	36.52	15.947
2	74.29	47.45	34.03	14.858	2	79.87	51.02	36.59	15.975
3	74.43	47.51	34.09	14.886	3	80.01	51.11	36.65	16.003
4	74.57	47.63	34.16	14.914	4	80.15	51.20	36.72	16.031
5	74.71	47.72	34.22	14.941	5	80.29	51.28	36.78	16.059
6	74.85	47.81	34.29	14.969	6	80.43	51.37	36.81	16.087
7	74.99	47.90	34.35	14.997	7	80.57	51.46	36.91	16.115
8	75.13	47.99	34.41	15.025	8	80.71	51.55	36.97	16.142
9	75.27	48.07	34.48	15.053	9	80.85	51.64	37.04	16.170
54.0	75.41	48.16	34.51	15.081	58.0	80.99	51.73	37.10	16.198
1	75.55	48.25	34.61	15.109	1	81.13	51.82	37.16	16.226
2	75.69	48.34	34.67	15.137	2	81.27	51.91	37.23	16.254
3	75.83	48.43	34.73	15.165	3	81.41	52.00	37.29	16.282
4	75.97	48.52	34.80	15.193	4	81.55	52.09	37.36	16.310
5	76.10	48.61	34.86	15.221	5	81.69	52.18	37.42	16.338
6	76.24	48.70	34.93	15.249	6	81.83	52.27	37.48	16.366
7	76.38	48.79	34.99	15.277	7	81.97	52.36	37.55	16.394
8	76.52	48.88	35.05	15.305	8	82.11	52.44	37.61	16.422
9	76.66	48.97	35.12	15.333	9	82.25	52.53	37.68	16.450
55.0	76.80	49.06	35.18	15.360	59.0	82.39	52.62	37.74	16.478
1	76.94	49.14	35.24	15.388	1	82.53	52.71	37.80	16.505
2	77.08	49.23	35.31	15.416	2	82.67	52.80	37.87	16.533
3	77.22	49.32	35.37	15.444	3	82.81	52.89	37.93	16.561
4	77.36	49.41	35.44	15.472	4	82.95	52.98	38.00	16.589
5	77.50	49.50	35.50	15.500	5	83.09	53.07	38.06	16.617
6	77.64	49.59	35.56	15.528	6	83.23	53.16	38.12	16.645
$Mg_2P_2O_7$	.01	.02	.03	.04	.05	.06	.07	.08	.09
$Ca_2P_2O_6$	.01	.03	.04	.06	.07	.08	.10	.11	.13
CaP_2O_6	.01	.02	.03	.04	.05	.05	.06	.07	.08
P_2O_5	.01	.01	.02	.03	.03	.04	.05	.05	.06
P_2	.003	.006	.008	.011	.014	.017	.020	.022	.025

TABLE FOR PHOSPHATES—continued.

Mg ₂ P ₂ O ₇	Ca ₃ P ₂ O ₈	Ca ₂ P ₂ O ₆	P ₂ O ₅	P ₂	Mg ₂ P ₂ O ₇	Ca ₃ P ₂ O ₈	CaP ₂ O ₆	P ₂ O ₅	P ₂
59.7	83.37	53.25	38.19	16.673	61.0	86.18	54.41	39.02	17.036
8	83.51	53.34	38.25	16.701	62	86.58	55.30	39.66	17.315
9	83.65	53.43	38.32	16.729	63	87.97	56.19	40.30	17.595
60.0	83.78	53.51	38.38	16.757	64	89.37	57.08	40.94	17.874
1	83.92	53.60	38.44	16.784	65	90.77	57.97	41.58	18.153
2	84.06	53.69	38.51	16.811	66	92.16	58.87	42.22	18.433
3	84.20	53.78	38.57	16.841	67	93.55	59.76	42.86	18.712
4	84.34	53.87	38.63	16.869	68	94.94	60.65	43.50	18.991
5	84.48	53.96	38.70	16.894	69	96.35	61.54	44.14	19.270
6	84.62	54.05	38.76	16.924	70	97.75	62.43	44.78	19.550
7	84.76	54.14	38.83	16.952	71	99.14	63.32	45.41	19.829
8	84.90	54.23	38.89	16.980		100.00	63.87	45.81	20.000
9	85.04	54.32	38.95	17.008					

TABLE FOR THE CONVERSION OF NITROGEN INTO AMMONIA AND ALUMINOIDS. (N = 6.25).

N.	NH ₃	Albuminoids (N = 6.25)	N.	NH ₃	Albuminoids (N = 6.25)	N.	NH ₃	Albuminoids (N = 6.25)	
0.1	0.12	0.63	1.9	2.31	11.88	3.7	4.48	23.43	
2	.24	1.25	2.0	2.43	12.50	8	9.61	23.75	
3	.36	1.88	4	2.55	13.13	9	4.74	24.38	
4	.49	2.50	2	2.67	13.75	4.0	4.80	25.00	
5	.61	3.13	3	2.79	14.38	1	4.98	25.63	
6	.73	3.75	4	2.91	15.00	2	5.10	26.25	
7	.85	4.38	5	3.04	15.63	3	5.22	26.88	
8	.97	5.00	6	3.16	16.25	4	5.34	27.50	
9	1.09	5.63	7	3.28	16.88	5	5.46	28.13	
1.0	1.21	6.25	8	3.40	17.50	6	5.58	28.75	
1	1.34	6.88	9	3.52	18.13	7	5.71	29.38	
2	1.46	7.50	3.0	3.64	18.75	8	5.83	30.00	
3	1.58	8.13	1	3.76	19.38	9	5.95	30.63	
4	1.70	8.75	2	3.88	20.00	5.0	6.08	31.25	
5	1.82	9.38	3	4.01	20.63	1	6.20	31.88	
6	1.94	10.00	4	4.13	21.25	2	6.32	32.50	
7	2.06	10.63	5	4.25	21.88	3	6.44	33.13	
8	2.19	11.25	6	4.37	22.50	4	6.57	33.75	
N.									
NH ₃									
Albuminoids	.01	.02	.03	.04	.05	.06	.07	.08	.09
	.01	.02	.04	.05	.06	.07	.09	.10	.11
	.06	.13	.19	.25	.31	.38	.44	.50	.56

TABLE FOR THE CONVERSION OF NITROGEN INTO AMMONIA AND ALBUMINOIDS *continued*.

N.	NH ₃	Albuminoids (N x 6.25).	N.	NH ₃	Albuminoids (N x 6.25).	N.	NH ₃	Albuminoids (N x 6.25).
5.5	6.60	31.38	9.1	11.06	53.88	12.6	15.32	78.75
6	6.81	35.00	9.2	11.19	57.50	7	15.41	79.38
7	6.93	35.67	5	11.31	58.13	8	15.56	80.00
8	7.05	36.25	4	11.43	58.75	9	15.68	80.63
9	7.17	36.88	3	11.55	59.38	13.0	15.81	81.25
6.0	7.29	37.50	6	11.67	60.00	1	15.93	81.88
1	7.42	38.13	7	11.79	60.63	2	16.05	82.50
2	7.54	38.75	8	11.92	61.25	3	16.17	83.13
3	7.66	39.38	9	12.04	61.88	4	16.29	83.75
4	7.78	40.00	10.0	12.16	62.50	5	16.41	84.38
5	7.90	40.63	1	12.28	63.13	6	16.54	85.00
6	8.02	41.25	2	12.40	63.75	7	16.66	85.63
7	8.15	41.88	3	12.52	64.38	8	16.78	86.25
8	8.27	42.50	4	12.64	65.00	9	16.90	86.88
9	8.39	43.13	5	12.77	65.63	11.0	17.02	87.50
7.0	8.51	43.75	6	12.89	66.25	1	17.14	88.13
1	8.63	44.38	7	13.01	66.88	2	17.27	88.75
2	8.75	45.00	8	13.13	67.50	3	17.39	89.38
3	8.88	45.63	9	13.25	68.13	4	17.51	90.00
4	9.00	46.25	11.0	13.37	68.75	5	17.63	90.63
5	9.12	46.88	1	13.50	69.38	6	17.75	91.25
6	9.24	47.50	2	13.62	70.00	7	17.87	91.88
7	9.36	48.13	3	13.74	70.63	8	17.99	92.50
8	9.48	48.75	4	13.86	71.25	9	18.12	93.13
9	9.61	49.38	5	13.98	71.88	15.0	18.24	93.75
8.0	9.73	50.00	6	14.10	72.50	1	18.36	94.38
1	9.85	50.63	7	14.23	73.13	2	18.48	95.00
2	9.97	51.25	8	14.35	73.75	3	18.60	95.63
3	10.09	51.88	9	14.47	74.38	4	18.72	96.25
4	10.21	52.50	12.0	14.59	75.00	5	18.85	96.88
5	10.33	53.13	1	14.71	75.63	6	18.97	97.50
6	10.46	53.75	2	14.83	76.25	7	19.09	98.13
7	10.58	54.38	3	14.95	76.88	8	19.21	98.75
8	10.70	55.00	4	15.08	77.50	9	19.33	99.38
9	10.82	55.63	5	15.20	78.13	16.0	19.45	100.00
9.0	10.94	56.25						

N	.01	.02	.03	.04	.05	.06	.07	.08	.09
NH ₃	.01	.02	.01	.05	.06	.07	.09	.10	.11
Albuminoids	.06	.13	.19	.25	.31	.38	.41	.50	.56

140 FACTORS FOR CALCULATING NITROGENOUS SUBSTANCES.

FACTORS FOR CALCULATING VARIOUS NITROGENOUS SUBSTANCES.

	Multiply Nitrogen by	Logarithm.	Authority.
Albuminoids	6.25	0.79588	...
Albumin	6.39	0.80550	Richmond
Casew	6.39	"	"
Proteins of cheese	6.39	"	"
" " milk	6.39	"	"
" " dried milk	6.38	0.80182	"
Gelatin	5.5	0.74036	Allen and Searle ; Mitchell
Proteins in meat-extract	6.33	0.80140	Allen and Searle
Hide substance (from nitrogen in leather)	5.62	0.74958	J. C. Parker

The comparative values of feeding stuffs are frequently expressed in terms of "food units," which are calculated as follows:

Multiply the sum of the percentages of oil and albuminoids by 2½ and add the percentage of digestible carbohydrates. The result gives the percentage of food units.

Exs. Two linseed cakes contained

	A	B
Oil	14.36	10.06
Albuminoids	27.42	28.50
Digestible carbohydrates	32.59	34.13

Hence we have

$$\begin{array}{r}
 \text{A} \quad 14.36 \\
 \quad 27.42 \\
 \hline
 41.78 \times 2\frac{1}{2} = 104.45 + 32.59 = \text{Food Units} \quad 137 \\
 \\
 \text{B} \quad 10.06 \\
 \quad 28.50 \\
 \hline
 38.56 \times 2\frac{1}{2} = 96.40 + 34.13 = 130.5.
 \end{array}$$

The relative values of A and B are thus

$$137 : 130.5, \text{ or } 1.05 : 1.$$

- It must be specially noticed that "food units" express the *total intrinsic value* of a feeding stuff - both as food, and as manure after it has passed through the animal.

* *Oyer, Fertilizers and Feeding Stuffs*, p. 81.

† Best done by using the equivalent fraction $\frac{10}{4}$, thus $\frac{4178}{4} = 104.45$.

OILS, FATS, AND WAXES.

Oils are neutral bodies of more or less viscous consistence, liquid at the ordinary temperature, combustible, lighter than water and insoluble in it, sometimes soluble in alcohol, and always soluble in ether. Oils are classified as follows:—(i), *fatty or fixed oils*; (ii), *essential or volatile oils*; and (iii) *Mineral oils*. The *volatile* or *fixed* oils are simply liquid fats, and, in contradistinction to the members of the second class, decompose when heated. *Essential oils* have strong and characteristic odours, and are vaporizable without decomposition, usually with little or no residue. Many essential oils consist of hydrocarbons or other fluid bodies mixed with solid oxidized compounds. On cooling such, or by evaporation, the latter often crystallize out, the solid thus separating being termed the *stearoptene*, whilst the liquid is called the *dacoptene*. *Mineral oils* form a class somewhat by themselves, and include petroleum and oils distilled from peat, shale, etc.; they consist of mixtures of hydrocarbons.

Fats are the (neutral) triglycerides of the higher fatty acids. A great many fats may be considered as mixtures of the triglycerides of several fatty acids, as of tripalmitin, tristearin and triolein; but mixed esters of glycerol may also exist in fats, e.g., oleopalmito-butyrate in butter-fat.

Waxes are esters formed by the union of mono- or dihydric alcohols with the higher fatty acids. The waxes, therefore, do not contain glycerol, and consequently, on being heated, do not emit the odour of acrolein, neither do they, on keeping, become rancid, owing to the stability of the esters of which they consist. Waxes are derived from both the animal and the vegetable kingdoms, beeswax being typical of the former, and carnauba wax of the latter.

Japan wax consists chiefly of glycerides, and hence is classed among "fats"; whilst sperm oil contains only a small amount of glycerides, but a large percentage of unsaponifiable matter, and is classed among "waxes."

(1) The *acid value* is the measure of the amount of free fatty acids in a fat or wax. It gives the number of milligrams of potassium hydroxide required to neutralize the free fatty acids in one gram of a fat or wax.

(2) The *saponification value*, or *Kottstorfer value*, is the number of milligrams of potassium hydroxide required to saponify completely one gram of a fat or wax (or gives grams of KOH required for 1000 grams of a fat or wax).

(3) The *ester value* gives the number of milligrams of potassium hydroxide required for the saponification of the neutral esters in one gram of a fat, or wax.

If a fat contains no free fatty acids, (3) is identical with (2); but in the more usual case, in which small quantities of free fatty acids are present, (3) is obtained by subtracting (1) from (2).

(4) The *iodine value* is the percentage of iodine chloride (10%) expressed in terms of iodine which is absorbed by an oil, fat, or wax.

(5) The *Hibner value* is the percentage of insoluble fatty acids + unsaponifiable matter in a fat or wax. For most fats it ranges from 95.5 to 96 per cent.

(6) The *Reichert Meissl value* is the number of c.c. of decinormal alkali required to neutralize the distillate of volatile acids obtained from 5 grams of a fat or wax by the Reichert distillation process.

(7) The *acetyl value* is the number of milligrams of potassium hydroxide required to neutralize the acetic acid obtained when 1 gram of an acetylated oil, fat, or wax is saponified.

Titler Test. This is the solidifying point in degrees Centigrade of the mixed fatty acids from an oil or fat.

Acid value $\times 0.502$ = free fatty acids (expressed as oleic).

TABLES OF CONSTANTS OF OILS, FATS, AND WAXES.
II.—ANIMAL OILS.

Name of Oil.	Sp. gr. @ 15.5-15.5° C.	Solidifying Point (°C.).	Rehner Value.	Saponifica- tion Value.	Iodine Value.	Oleo-refractometer (Jean, @ 25° C.).	Butyro-refracto- meter (Zell).
Cod liver	0.922-0.930	0 to -10	25.5	179-191	154-170	+40 to +48	74-77 @ 30° C.
Lard oil	0.918-0.919	-4 to +10	37	193-195	65-82	0 to -1	5-6 @ 8° C.
Neat's foot	0.914-0.917	3 to -4	94.5-95.9	194-199	96-78	-1 to -4	5-6 @ 30° C.
Seal	0.924-0.929	-2 to -3	93-96	190-196	130-152	-2 to -2.30	64-75 @ 40° C.
Shark liver	0.916-0.919	..	57-97	157-164	110-139	+20 to +35	..
Sheep's foot	0.9175	0 to 1.5	..	194.75	74-74.4	0	..

III.—ANIMAL FATS.

Name of Fat.	Sp. gr. @ 15.5° C.	Solidifying Point (°C.).	Rehner Value.	Saponifica- tion Value.	Iodine Value.	Oleo-refractometer (Jean).	Butyro-refracto- meter (Zell).
Lard	0.880-0.901	27-29	93-95	195-203	59-68	-7 to -1.6 @ 15° C.	55.5-57 @ 30° C.
Beef Tallow	0.860-0.901	38-46	95-96	194-200	40-47	-15 to -18 @ 45° C.	40 @ 40° C.
Mutton Tallow	0.855-0.900	40-43	95-96	192-195	5-13	..	..

- 30 and 100° F. 100° F.

+ 1.0035-0.7 @ 100° F. 100° F.

TABLES OF CONSTANTS OF OILS, FATS, AND WAXES.
IV.—VEGETABLE FATS.

Name of Fat	Sp. Gr. 15.5° C. 15.5° 15.5° C.	Melting Point ° C.	Refractive Value.	Saponification Value.	Iodine Value.	Butyrolin, etc., met-% test
Cacao butter	0.964-975	32-34		152.15	84.98	45 (6-40.5 at 40° C.)
Coco-nut oil	0.910-93.7	23-27	52.450	251.96	8.95	35 (40.5 at 30° C.)
Japan wax	0.984-0.98	50-56	60.903	274.25	42.11	
Nutmeg butter (orce butter)	0.945-0.96	41-51		174.65	48.87	55 (67.2 at 40° C.)
Palm oil	0.921-0.924	27-44	94.597	200.50	78	
Shea butter (Galan butter)	0.9175-928	23-28	94.8	200.10	31.7	

V.—WAXES.

Name of Wax	Sp. Gr. 15.5° C. 15.5° 15.5° C.	Melting Point ° C.	Refractive Value.	Saponification Value.	Iodine Value.	Butyrolin, etc., met-% test
Beeswax	0.858-0.863	60-62	18.21	95.60	7.78	48 (40.5 at 40° C.)
Carnauba wax	0.908-1.000	80-86	4.8	79.84	13.5	65 (60.5 at 40° C.)
Chinese wax (Jusset wax)	0.975	51-53	5.5	80.60	7.4	
Spermaceti	0.94-0.969	48-49	6.15	122.27	4.4	
Sperm oil	0.875-0.884			123-144	51-87	50 (2.5 at 40° C.)
Woolfat (lanolin)	0.97	90-11	0.2-0.8	48.10	1-27	

* At 50° F. to 60° F.

† Unsaponifiable matter, 33-40. Fatty acids, 57-61.

APPENDIX.

Name of oil.	Sp. gr. at 15.5/15.5° C.	Saponifica- tion value.	Iodine value	Butyro refractometer.
Chinese wood (Tung) (D)	0.940-944	192-196	166-176	†
Palm kernel	0.866-873	211-250	15-23	36.5 @ 40° C.
Soya bean (D)	0.921-927	190-193	126-135	63 @ 40° C.
Whale	0.917-927	187-190	110-125	56-59 @ 40° C.

At 30/15.6 C.

† Ref. index at 20°, 1.538.

TABLE SHOWING REICHERT-MESSL VALUES FOR CERTAIN
OILS, FATS, AND WAXES.

(c.c. N/10 alkali required by 5 grams.)

Almond oil	0.5	Nutmeg seed oil	0.9-1.2
Apricot kernel oil	0.0	Nutmeg butter	0.1-0.63
Arachis oil	0.0-1.6	Olive oil	1-4.2
Beeswax	0.34-0.54	Palm oil	0.6
Cacao butter	1.0	Palm kernel oil	0.8-1.9
Castor oil	1.1	Rape oil	5-6.8
Coco-nut oil	6.5-8	Sesame oil	0.0-6.8
Cod-liver oil	0.4-0.8	Soya bean oil	1-2
Cotton-seed oil	0.7-0.9	Sperm oil	below 1
Croton oil	12-13.5	Tallow	0.6
Lard	0.5-0.77	Whale oil	0.5
Linseed oil	0.0	Wheat oil	0.7-2.0
Maize oil	4-4.5		2.5

AVERAGE POLENSKI VALUES OF OILS.

Arachis, cacao, cotton, Chinese vegetable tallow, hempseed, lard, linseed, maize, niger, olive, palm, poppyseed, rape, sesame, soya, stearine, sun flower, tallow—each below 1.

Butterfat	2-3	Margarine containing no	
Coco-nut	16.5	coco-nut oil	0.5
Palm kernel	10-12	Cacao butter	0.5
Oleo-oil	0.55		

OILS AND FATS.

TABLE OF SAPONIFICATION VALUES.

5 Grams Saponified.

1 c.c. N/2 acid - 0.02805 gram KOH (log. 2.44793).

No. of c.c. N/2 acid used.	Saponification value	No. of c.c. N/2 acid used	Saponification value.
	+0.1 c.c. = +0.56		+0.1 c.c. = +0.56
30.0	168.30	31.0	173.91
2	169.42	2	175.03
4	170.54	4	176.15
6	171.67	6	177.28
8	172.79	8	178.40

OILS AND FATS.

TABLE OF SAPONIFICATION VALUES - *continued*.

5 Grams Saponified

1 c.c. N/2 acid = 0.02805 gram KOH *log. 2.1473

No. of c.c. N/2 acid used	Saponification value	No. of c.c. N/2 acid used	Saponification value
	0.1 c.c. = 0.056		0.1 c.c. = 0.056
32.0	179.52	37.8	12.00
"2	180.64	38.0	213.18
"4	181.76	"2	14.30
"6	182.89	"4	15.42
"8	184.01	"6	216.55
33.0	185.15	"8	217.67
"2	186.25	33.0	218.79
"4	187.37	"2	219.91
"6	188.50	"4	221.03
"8	189.62	"6	222.16
34.0	190.74	"8	223.28
"2	191.86	40.0	224.40
"4	192.98	"2	225.52
"6	194.11	"4	226.64
"8	195.23	"6	227.77
35.0	196.35	"8	228.89
"2	197.47	41.0	229.90
"4	198.59		
"6	199.72	1.0	5.61
"8	200.84	2.0	11.22
36.0	201.96	3.0	16.83
"2	203.08	4.0	22.44
"4	204.20	5.0	28.05
"6	205.33	6.0	33.66
"8	206.45	7.0	39.27
37.0	207.57	8.0	44.88
"2	208.69	9.0	50.49
"4	209.81	10.0	56.10
"6	210.94		

The *Saponification Equivalent* of a fat is the number of grams that would be saponified by 1 litre of a normal solution of any alkali. It is the quotient obtained by dividing 561.08 by the saponification value.

BUTYRO REFRACTOMETER.—TABLE FOR CONVERSION OF SCALE READINGS INTO REFRACTIVE INDICES (n_D) FOR YELLOW LIGHT.*

Scale reading ₁	n_D	Scale reading ₂	n_D	Scale reading ₃	n_D
10	1.4430	49	1.4586	72	1.4735
15	1.4328	50	1.4593	73	1.4741
20	1.4377	51	1.4590	74	1.4747
25	1.4415	52	1.4606	75	1.4753
30	1.4452	53	1.4613	76	1.4759
31	1.4459	54	1.4619	77	1.4765
32	1.4466	55	1.4626	78	1.4771
33	1.4474	56	1.4635	79	1.4777
34	1.4481	57	1.4639	80	1.4783
35	1.4488	58	1.4643	81	1.4789
36	1.4495	59	1.4647	82	1.4794
37	1.4502	60	1.4652	83	1.4800
38	1.4510	61	1.4655	84	1.4806
39	1.4517	62	1.4672	85	1.4812
40	1.4524	63	1.4678	86	1.4817
41	1.4531	64	1.4685	87	1.4823
42	1.4538	65	1.4691	88	1.4829
43	1.4545	66	1.4697	89	1.4834
44	1.4552	67	1.4704	90	1.4840
45	1.4559	68	1.4710	95	1.4868
46	1.4565	69	1.4717	100	1.4895
47	1.4572	70	1.4723		
48	1.4579	71	1.4729		

• *Correction for Temperature (Wright).*—The following formula is applicable to all fatty oils:

Let n_t be the refractive index at $t^\circ \text{C}$.

Then $n_{40} = n_t \times \frac{t}{40}$.

$$n_{40} = (n_t - 1) \times \frac{1 - 0.00076t}{1 - 0.00076t} + 1.$$

Where $t = 40^\circ \text{C}$, the formula becomes

$$n_{40} = (n_t - 1) \times \frac{0.9996}{1 - 0.00076t} + 1.$$

Ex. Olive oil. Ref. index at 30°C . is 1.4657.

Then

$$n_{40} = 0.4657 \times \frac{0.9996}{1 - 0.00076 \times 30} + 1 = 1.4621.$$

* The values here given have been obtained by interpolation from the short table supplied by Zeiss with each instrument.

† See *Annuaire Soc. Chem. Ind.*, 1919, 38, 392 T.

SOURCE OF VOLATILE ACIDS IN BUTTER FAT.

5 Grams Butter Fat being taken.

c.c. N 10 Alkali.	% Soluble of Volatile Acids.	Z			
		c.c. N 10 Alkali.	% Soluble of Volatile Acids.	c.c. N 10 Alkali.	% Soluble of Volatile Acids.
1.0	0.18	16.5	2.58	16.9	4.52
1.5	0.26	17.5	2.16	20.7	1.86
2.0	0.35	18.5	2.55	22.0	4.75
2.5	0.44	19.5	2.61	27.5	1.81
3.0	0.55	20.5	2.75	18.0	1.93
3.5	0.62	19.0	2.82	28.5	5.02
4.0	0.70	16.7	2.90	29.0	5.10
4.5	0.79	17.0	2.99	29.5	5.19
5.0	0.88	17.5	3.05	30.5	5.28
5.5	0.97	18.0	3.17	31.5	5.37
6.0	1.06	18.5	3.26	31.0	5.16
6.5	1.14	19.0	3.34	31.5	5.11
7.0	1.23	19.5	3.46	32.0	5.15
7.5	1.32	20.0	3.50	32.5	5.72
8.0	1.41	20.5	3.61	33.5	5.81
8.5	1.50	21.0	3.70	34.5	5.90
9.0	1.58	21.5	3.78	34.0	5.98
9.5	1.67	22.0	3.87	34.5	6.07
10.0	1.76	22.5	3.96	35.0	6.16
10.5	1.85	23.0	4.05		
11.0	1.94	23.5	4.14	0.1	0.02
11.5	2.02	24.0	4.22	0.2	0.04
12.0	2.11	24.5	4.31	0.3	0.05
12.5	2.20	25.0	4.40	0.4	0.07
13.0	2.29	25.5	4.49		

* Calculated as Butyric Acid. * 416.7-88

LIMIT OF BUTTER-FAT ALLOWED IN MARGARINE.

Section 8 of the "Sale of Food and Drugs Act, 1899" enacts that it is unlawful to manufacture, sell, or import any margarine the fat of which contains more than 10 per cent. of butter fat.

BUTTER AND MARGARINE ACT, 1907.

The following provisions of the above are of importance to the Public Analyst:—

Section 4 (1) fixes the limit of water in butter and margarine at 16 per cent., and by sub-section (2) the limit of water in milk-blended butter is 21 per cent.*

Section 13 is as follows: (1) For the purposes of the Sale of Food and Drugs Acts and this Act the expression "Margarine" shall mean any article of food, whether mixed with butter or not, which resembles butter and is not milk-blended butter. (2) The above definition shall be substituted for the definition of margarine in the Margarine Act, 1887. This latter was as follows: The word "Margarine" shall mean all substances, whether compounds or otherwise, prepared in imitation of butter, and whether mixed with butter or not.

TABLE SHOWING THE VARIATIONS IN REICHERT-WOLLNY NUMBER, ETC., OF BUTTER AND MARGARINE. †

	Butter.		Margarine.
	Mean.	Variations.	
Reichert-Wollny number	28·4 c.c.	21·2-35 c.c.	0·0-0·3 c.c.
Insoluble fatty acids	87·75%	85·6-89·6%	95-96%
Soluble fatty acids	5·58%	4·6-7·0%	trace
Buero - refractometer (Zeiss) at 35° C.	46·0	43·8-49	52-56
Iodine absorption .	37·4%	31·6-42·0%	50-60%
Sp. gr. 100° F / 100°	0·9117	0·9105-0·9122	0·901-0·903
Potash absorption .	22·58%	22·01-22·98%	19·4-19·6%

THE INTERDEPENDENCE OF THE PHYSICAL AND CHEMICAL CRITERIA IN THE ANALYSIS OF BUTTER-FAT.

During 1901-2 over four hundred samples of butter were taken from farms or creameries in various parts of the United Kingdom, including the Orkney's, Shetlands and Hebrides, the samples being specially selected with the view of ascertaining by analysis the extent to which the chemical nature of butter-fat is dependent on the climatic influences to which the cows are exposed, on the nature and amount of the food supplied, and on the breed, period

* From the Report of the official method for determining the percentage of butter-fat in margarine (see *The Analyst*, 1900, p. 510).

† By H. Drouot Richmond, see Appendix XXI. to the *Final Report of the Departmental Committee on Butter Regulations*, 1904.

of lactation, and idiosyncrasy of the individual cow. Of the samples collected, 357 were fully analysed in the Government Laboratory, and the results, which are fully recorded in supplements to the report already referred to, form the subject of a paper with the above title* by Dr T. E. Thorpe, C.B., F.R.S. The results are summarized in the subjoined table:-

Butter-fat.	357 samples examined		
	39 samples (10.9%)	28 samples (8.1%)	28 samples (7.9%)
Reichert-Wallace number	22.5 - 24.5	25.5 - 30.5	31.3 - 32.8
Sp. gr. 100° F./100 l.	0.9101 - 0.9108	0.9110 - 0.9123	0.9125 - 0.9130
Saponification equivalent	213.4 - 213.8	211.1 - 212.4	211.3* - 211.2
(Koeffizienten number)	2.307 - 2.298	2.270 - 2.310	2.319 - 2.322
Butyro-refractometer (Zeiss) at 45° C.	4.2 - 4.5	41.3 - 39.9	39.7 - 39.4
Soluble acids %	1.7 - 4.7	1.8 - 5.7	5.8 - 6.0
Insoluble acids %	3.1 - 39.4	89.3 - 87.9	77.9 - 87.7

Dr Thorpe makes the following comment:-

"It will be seen that, in a general sense, the relative density of butter-fat increases as the Reichert-Wallace number is augmented. This would, of course, follow from the well-known fact that the glycerides of low molecular weight have a greater density than the glycerides of the higher fatty acids which occur in butter." . . .
 "Speaking broadly, the variations of the saponification numbers are in inverse relation to those of the Reichert-Wallace values and the relative density. . . . The Zeiss numbers generally decrease in magnitude as the Reichert-Wallace values increase, but the rate of diminution is not regular." ‡

BOARD OF AGRICULTURE RULES.

Sale of Butter Regulations, 1902.

Where the proportion of water in a sample of butter exceeds 16 per cent., it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1899, until the contrary is proved, that the butter is not genuine by reason of the excessive amount of water therein.

This regulation extends to Great Britain, and came into operation on 15th May 1902.

* *Journ. Chem. Soc.*, 1901, pp. 438-256.

† Calculated as butyric acid.

‡ These relations are deduced from curves plotted from the averages of the various analytical results.

152 CALCULATION OF THE RESULTS OF MILK ANALYSES.

The Departmental Committee on butter regulations, in their Final Report, dated 1st December 1903, recommend :—

(1) That the figure 21, arrived at by the Reichert-Wollny method, should be the limit below which a presumption should be raised that butter is not genuine.

(2) That the use of 10 per cent. of sesamé oil in the manufacture of margarine be made compulsory.

(3) That steps should be taken to obtain international co-operation.

Two members of the Committee, however, favoured the Reichert-Wollny number of 23 instead of 21. A third member, who did not sign the Report of the majority, stated in a separate report that he considered it would be "highly dangerous" to fix any limit at present.

CALCULATION OF THE RESULTS OF MILK ANALYSES.

According to the "Sale of Milk Regulations 1901" (see p. 153), milk is to be presumed not to be genuine if the non-fatty solids fall below 8.5 per cent., or the milk-fat below 3 per cent.

The calculation of the amount of added water in the case of samples whose non-fatty solids fall below the above limit is made as follows :—

Since 8.5 parts of non-fatty solids corresponds to 100 parts of genuine (*i.e.*, presumably genuine) milk, S parts of non-fatty solids correspond to $\frac{100}{8.5} \times S$ of genuine milk; and 100 parts of the water'd sample will contain

$$100 - \frac{100S}{8.5} = 100 - 8.5S \text{ of added water.}$$

Since $\log. \frac{100}{8.5} = 1.07058$, we have

$$\log. \text{ of percentage of added water} = 1.07058 +$$

$\log. (8.5 \text{ per cent. of non-fatty solids found}).$

We will now consider two examples.

	Example I.	Example II.
Non-fatty solids	7.60 per cent.	7.89
Fat	2.80 "	2.25
Example I. $8.50 - 7.60 = 0.90$.		
	1.07058	
log. 0.9	1.95424	

$$1.02482 = \log. 10.6 \therefore \text{at least } 10.6 \text{ per cent. of added water.}$$

A mixture of 90 parts of genuine milk and 10 parts of added water should contain $\frac{90}{100} \times 3 = 2.7$ per cent. at least of fat.

The sample contains 2.8 per cent., and hence contains proportionately a little more fat than that given in the Regulation.

Example II. 8.50 7.89 0.61,

1.07058

log. 0.61 = 1.78523

0.85591 log. 7.2, i. e. at least 7 per cent. of added water.

A mixture of 93 parts of genuine milk and 7 parts of added water should contain 0.93×2.25 per cent. at least of fat. The sample contains only 2.25 per cent., and is, therefore, $\frac{100(2.79 - 2.25)}{2.79}$ = 19 per cent. deficient in milk fat as well.

Or thus: In this case 93 parts of "milk" contain 2.25 parts of fat, or 100 parts would contain $\frac{100}{93} \times 2.25 = 2.42$ of fat, which is below the minimum allowed. Hence the milk had been deprived of $\frac{100(2.42 - 2.25)}{2.42} = 7$ per cent. of its fat in addition to being watered to the extent of 7 per cent.

BOARD OF AGRICULTURE RULES

Sale of Milk Regulations, 1901.

Milk.

1. Where a sample of milk (not being milk sold as skimmed, or separated, or condensed, milk) contains less than 3 per cent. of milk-fat, it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1907, until the contrary is proved, that the milk is not genuine, by reason of the abstraction therefrom of milk-fat, or the addition thereto of water.

2. Where a sample of milk (not being milk sold as skimmed, or separated, or condensed, milk) contains less than 8.5 per cent. of milk-solids other than milk-fat, it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1907, until the contrary is proved, that the milk is not genuine, by reason of the abstraction therefrom of milk-solids other than milk-fat, or the addition thereto of water.

The above Regulations, which extend to Great Britain, came into force on Sept. 1, 1901, and still hold good.

Regulation 3, however, was revoked by "The Sale of Milk Regulations, 1912," and the following substituted for it:—

Skimmed or Separated Milk.

Where a sample of skimmed or separated milk (not being condensed milk) contains less than 8.7 per cent. of milk solids other than milk-fat, it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1907, until the contrary is proved, that the milk is not genuine, by reason of either the addition thereto of water, or the abstraction therefrom of milk solids other than milk-fat.

This Regulation extends to England and Wales, and came into operation on Sept. 1, 1912.

TABLE GIVING THE PERCENTAGE DEFICIENCY OF NON-FATTY SOLIDS (N.F.S.) IN MILK IN WHICH THESE ARE BELOW THE LEGAL MINIMUM OF 8.5 PER CENT.

Non-fatty Solids.	Deficiency in N.F.S.	% Non-fatty Solids	Deficiency in N.F.S.	% Non-fatty Solids	Deficiency in N.F.S.				
4.0	52.90	5.5	35.29	7.0	17.65				
4.1	51.76	6	31.12	8	16.47				
4.2	50.59	6.7	32.94	9	15.29				
4.3	49.41	7	31.76	10	14.12				
4.4	48.21	7.9	30.59	11	12.94				
4.5	47.06	8.0	29.41	12	11.76				
4.6	45.88	9	28.21	13	10.59				
4.7	44.71	10	27.06	14	9.41				
4.8	43.53	11	25.88	15	8.21				
4.9	42.35	12	24.71	16	7.06				
5.0	41.18	13	23.53	17	5.88				
5.1	40.00	14	22.35	18	4.71				
5.2	38.82	15	21.18	19	3.53				
5.3	37.65	16	20.00	20	2.35				
5.4	36.47	17	18.82	21	1.18				
	.01	.02	.03	.04	.05	.06	.07	.08	.09
Subtract	.12	.23	.35	.47	.59	.71	.82	.94	1.06

Ex.—A sample of "milk" containing 7.76% of non-fatty solids would thus show a deficiency of $15.29 - .71 = 14.58\%$.

TABLE SHOWING THE DEFICIENCY IN FAT IN CREAMED MILK.

% Milk-fat.	% Deficiency in Fat.	% Milk fat	% Deficiency in fat.	% Milk-fat	% Deficiency in Fat.
0.1	96.67	1.1	63.33	2.1	30.00
0.2	93.33	2	60.00	3	26.67
0.3	90.00	3	56.67	4	23.33
0.4	86.67	4	53.33	5	20.00
0.5	83.33	5	50.00	6	16.67
0.6	80.00	6	46.67	7	13.33
0.7	76.67	7	43.33	8	10.00
0.8	73.33	8	40.00	9	6.67
0.9	70.00	9	36.67	10	3.33
1.0	66.67	10	33.33	...	...

	.01	.02	.03	.04	.05	.06	.07	.08	.09
Subtract.	0.33	0.67	1.00	1.33	1.67	2.00	2.33	2.67	3.00

MILK ANALYSIS.
Table to find the sp. gr. of Milk at 60° Fah. from its sp. gr. at any Temperature between 50° and 70° Fah. (water=1000).

Fah.	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035
50	19.2	20.2	21.2	22.2	23.2	24.1	25.1	26.1	27.0	28.0	29.0	29.9	30.9	31.8	32.7	33.6
51	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
52	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
53	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
54	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
55	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
56	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
57	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
58	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
59	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
60	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
61	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
62	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
63	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
64	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
65	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
66	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
67	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
68	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
69	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The observed sp. gr. is given at the top of each column, and the number in the column opposite to the temperature at which the sp. gr. was determined added to 1000 gives the sp. gr. at 60° F.

Ex. 1. Milk of which the sp. gr. is 1072 at 54° F. is 1072 + 31.8 at 60° F.

Ex. 2. Milk of which the sp. gr. is 1028.6 at 60° F. becomes 1060 + (28.4 + 0.6) = 1029 at 60° F.

PRESERVATIVES IN MILK AND CREAM.

According to the provisions of "The Public Health (Milk and Cream) Regulations, 1912," the addition of any preservative substance to milk (including separated, skimmed, condensed, and dried milk) or to cream, containing less than 35 per cent. by weight of milk-fat is prohibited. The addition of any thickening substance (*i.e.* mucrate of lime, gelatin, starch paste, etc.) to cream, whether containing preservative or not, is also prohibited. Cream containing 35 per cent. or more by weight of milk fat may contain no other preservative than (i) boric acid, borax, or a mixture of those preservative substances, or (ii) hydrogen peroxide.

By the Amending Order of the above (dated February 8, 1917) the maximum amount of boric preservative calculated as boric acid (H_3BO_3) allowed in preserved cream is 0.1 per cent. Two types of label were ordered to be used, thus (i) Preserved cream containing boric acid not exceeding — per cent., (ii) Preserved cream (peroxide) — with the addition in each case of the statement "not suitable for infants or invalids." The above Order came into operation on April 2, 1917.

QUININE.

Hydrochloride of quinine, $(C_{20}H_{24}N_2O_2 \cdot HCl, 2H_2O).$	Sulphate of quinine, $2[(C_{20}H_{24}N_2O_2)_2 \cdot H_2SO_4] \cdot 5H_2O$
306.712.	1763.24
Percentage composition.	Percentage composition.
$C_{20}H_{24}N_2O_2$ 81.73	$C_{20}H_{24}N_2O_2$ 73.55
HCl 9.19	H_2SO_4 11.12
H_2O 9.08	H_2O 15.33
100.00	100.00
To convert	
$C_{20}H_{24}N_2O_2$ into $C_{20}H_{24}N_2O_2 \cdot HCl, 2H_2O$	Multiplier 1.2336
.. $2[(C_{20}H_{24}N_2O_2)_2 \cdot H_2SO_4] \cdot 5H_2O$	Log to be added 0.08765
	1.360
	0.13343

Tincture of quinine, B.P. 1914, contains 2 grams of quinine hydrochloride in 100 c.c.

J. W. T. JONES'S METHOD FOR THE ESTIMATION OF CHICORY IN MIXTURES OF COFFEE AND CHICORY.

The sample is dried in the water-oven, and 50 grains are weighed into a large porcelain dish. About 200 c.c. of water are added, and boiled for 15 minutes. After allowing a minute or two for settling, the liquid is strained through a piece of copper gauze placed in a funnel into a 250 c.c. measuring flask, care being taken not to disturb the grounds as little as possible. The latter are now treated with about 50 c.c. of water, boiled for 5 minutes, and the liquid strained off as before. The flask is then cooled, made up to the mark, well shaken and filtered, the liquid being poured on a dry filter; 50 c.c. of the filtrate (i.e. 1 gram of the coffee mixture) are then pipetted into a weighed, flat-bottomed glass dish, evaporated to dryness over a steam-bath, and finally dried in the water-oven. The results are returned to the nearest percentage of chicory (see Table on p. 158).

Treated as above, chicory gives a mean percentage extract of 50; while coffee gives a remarkably constant percentage extract of 24.

To determine the percentage of chicory from the weight of extract obtained, we proceed as follows:—

$$\begin{array}{rcl}
 \text{Let } x & = & \text{percentage of chicory,} \\
 100 - x & & \text{coffee} \\
 \text{and let } E & & \text{extract found.} \\
 \therefore 0.7 \times 24.16 + x = E \\
 0.7x + 24 \cdot 216 = E \\
 46x - E = 24 \cdot 24 \\
 x = \frac{E - 24 \cdot 24}{46}
 \end{array}$$

Putting $x = 1$, we find $E = 24.16$, and the table on page 158 is in this way easily calculated.

Note.—By the above method E. W. T. Jones obtained the excellent results recorded in *The Analyst*, 1882, 7, 76, in the case of the Birkenhead "Coffee" samples.

LEAD IN TARTARIC AND CITRIC ACIDS AND IN CREAM OF TARTAR.

Dr MacFadden, in a Report^{*} to the Local Government Board,^{*} recommends the adoption of a limit of 0.002 per cent. (approximately $\frac{1}{50}$ th grain per lb.) of lead as impurity in tartaric acid, citric acid, and cream of tartar.

^{*} Report (No. 2) on Lead and Arsenic in Tartaric Acid, Citric Acid and Cream of Tartar, 1907.

TABLE SHOWING THE PERCENTAGE OF CHICORY WITH COFFEE FROM,
THE PERCENTAGE OF AQUEOUS EXTRACT.

Extract per cent.	Chicory per cent.	Extract per cent.	Chicory per cent.	Extract per cent.	Chicory per cent.
24.46	1	40.10	35	55.28	68
.92	2	.56	36	.74	69
25.38	3	41.02	37	56.20	70
.84	4	.48	38	.66	71
26.30	5	.94	39	57.12	72
.76	6	42.40	40	.58	73
27.22	7	.86	41	58.04	74
.68	8	43.32	42	.50	75
28.14	9	.78	43	.96	76
.60	10	44.24	44	59.42	77
29.06	11	.70	45	.88	78
.52	12	45.16	46	60.34	79
.98	13	.62	47	.80	80
30.44	14	46.08	48	61.26	81
.90	15	.54	49	.72	82
31.36	16	47.00	50	62.18	83
.82	17	.46	51	.64	84
32.28	18	.92	52	63.10	85
.74	19	48.38	53	.56	86
33.20	20	.84	54	64.02	87
.66	21	49.30	55	.48	88
34.12	22	.76	56	.94	89
.58	23	50.22	57	65.40	90
35.04	24	.68	58	.86	91
.50	25	51.14	59	66.32	92
.96	26	.60	60	.78	93
36.42	27	52.06	61	67.24	94
.88	28	.52	62	.70	95
37.34	29	.98	63	68.16	96
.80	30	53.44	64	.62	97
38.26	31	.90	65	69.08	98
.72	32	54.36	66	.54	99
39.18	33	.82	67	70.00	100
.64	34				

FOOD PRESERVATIVES.

The Departmental Committee on Food Preservatives appointed in 1899 in their Report,* issued in 1901, make the following recommendations:—

- (a) That the use of formaldehyde or formalin, or preparations thereof, in food or drink be absolutely prohibited, and that salicylic acid be not used in a greater proportion than 1 grain per pint in liquid food, and 1 grain per pound in solid food. Its presence in all cases to be declared.
- (b) That the use of any preservative or colouring matter whatever in milk offered for sale in the United Kingdom be constituted an offence under the Sale of Food and Drugs Act.†
- (c) That the only preservative which it shall be lawful to use in cream be boracic acid, or mixtures of boracic acid and borax, and in amount not exceeding 0·25 per cent. expressed as boracic acid. The amount of such preservative to be notified by a label upon the vessel.
- (d) That the only preservative permitted to be used in butter and margarine be boracic acid, or mixture of boracic acid and borax, to be used in proportion not exceeding 0·05 per cent. expressed as boracic acid.
- (e) That in the case of all nutritive preparations intended for the use of invalids or infants, chemical preservatives of all kinds be prohibited.
- (f) That the use of copper salts in the so-called preserving of preserved foods be prohibited.
- (g) That means be provided either by the establishment of a separate court of reference, or by the imposition of more direct obligation on the Local Government Board, to exercise supervision over the use of preservatives and colouring matters in foods, and to prepare schedules of such as may be considered inimical to the public health.

With regard to the recommendation marked (f), Dr. Thoma-Lille, a member of the Committee, points out the value of appearance in rendering foods appetising, and recommends that not more than the equivalent of half a grain of metallic copper per pound should be allowed to be added, the actual amount used being declared.

ARSENIC IN FOOD.

In the Final Report of the Royal Commission appointed to inquire into Arsenical Poisoning, issued in November 1903, the Commissioners state (Part VIII., p. 50), that "In our view it would be entirely proper that penalties should be imposed under the Sale of Food and Drugs Acts upon any vendor of beer or any other liquid food, or of any liquid entering into the composition

* Report of Departmental Committee on Preservatives and Colouring Matters in Food, 1901, pp. xxx and xxxi.

† See also Circular issued by the Local Government Board, July 11, 1906 (reprinted in *The Analyst*, 1906, 31, 278).

of food, if that liquid is shown by an adequate test to contain $\frac{1}{100}$ th of a grain or more of arsenic in the gallon; and, with regard to solid food—no matter whether it is habitually consumed in large or in small quantities, or whether it is taken by itself (like golden syrup) or mixed with water or other substances (like chicory or ‘carnos’)—if the substance is shown by an adequate test to contain $\frac{1}{100}$ th grain of arsenic or more in the pound.”

Note. In the above “arsenic” is taken to mean *arsenous oxide* (As_2O_3).

HEAT AND THERMO-CHEMISTRY.

The C.G.S. unit of heat is the calorie, which is the quantity of heat required to raise 1 gram of water through 1°C .

The large or major calorie is the quantity of heat required to raise 1 kilogram of water through 1°C . in the neighbourhood of 15°C . This is the metric unit of heat adopted for technical purposes and is known as the K.C.U.

The British Thermal Unit (B.Th.U.) is the amount of heat required to raise 1 lb. of water through 1°Fah. in the neighbourhood of 63°F . Hence

$$1 \text{ K.C.U.} = 3.9683 * \text{ (or approximately 4) B.Th.U.}$$

$$1 \text{ B.Th.U.} = 0.252 \text{ (or approximately } \frac{1}{4} \text{) K.C.U.}$$

The “Pound Centigrade Unit” is the quantity of heat required to raise 1 lb. of water 1°C .

The ratio of this unit to the B.Th.U. is obviously that of the degree Centigrade to the degree Fahrenheit, viz. $5:9$ or $1:1.8$, and $1 \text{ B.Th.U.} = \frac{9}{5} = 0.555 \text{ lb. Centigrade Unit}$. To convert lb. Cent. Units into B.Th.U. multiply by two and subtract one-tenth. Thus 6000 of the former $= 16,000 - 1600 = 14,400 \text{ B.Th.U.}$

The Evaporative Power (E.P.) of fuel is the number of pounds of water at 212°F. which would be converted into steam by the combustion of 1 lb. of fuel. The latent heat of vaporization of water is $537^\circ \text{Centigrade}$ or $967^\circ \text{Fahrenheit}$ units, hence

$$\text{E.P.} = \frac{\text{B.Th.U.}}{967} = \text{calorific power in calories.}$$

The values of the mechanical equivalent of heat, that is, the number of units of mechanical work equivalent to one unit of heat, or Joule’s equivalent (designated by the letter J), are usually taken to be as follows:—

* Thus, the quantity of heat that will raise 1 kilog. through 1°C . will raise its equivalent, 2.2046 lb. through 1.8°F. , or 1 lb. through $2.2046 \times 1.8 = 3.9683^\circ \text{F.}$

777 foot-pounds are equivalent to 1 B.Th.U. (lb. deg. Fah.).

1399 " " " " " 1 lb. deg. C.

426.3 kilogrammetres " " " 1 kilogram-deg. C. or kilocalorie.

4.180 joules " " " 1 gram-deg. C. or calorie.

The water for the heat units is supposed to be taken at 20° C. (68° F.) and the degree of temperature is supposed to be measured by the hydrogen thermometer.

*Heat evolved in calories (water grain degrees) on burning 1 gram of:—

Hydrogen to water at 0°	34,000
Carbon to carbon dioxide	8,080
" " " " " " " "	2,116
Alcohol (absolute)	7,181
Anthracite	9,200 9,500
Brquettes	2,800 3,300
Bituminous coal	8,000 9,600
Coke (dry)	7,100 6,860
Wood (with 20 per cent. water)	2,500 5,000
Wood charcoal	7,100 7,000
Lignite	6,500 7,000
Peat (air dried)	4,200 4,307
Light petroleum (sp. gr. 0.700-0.705)	11,300 11,520
Petrol (sp. gr. 0.684)	11,520
Petroleum	10,900
Shale oil, Tar oil, and Creosote oil	8,800
Methylated spirit	6,200
Liquid fuels range from 9,000-11,000 calories per gram	

Note. The above figures also give caloric values in pound centigrade units per lb. of substance burnt.

The following results are useful:—

Fuel	Sp. gr.	B.Th.U. per lb.	B.Th.U. per gallon.
Petrol	0.738	18,750	138.375
Benzole (50 per cent.)	0.872	17,830	155.478
" " "	0.887	17,600	155.440

In the case of fuels containing hydrogen (e.g. coal) the *gross* caloric value (the one usually employed) is that in which the heat liberated by the condensation of the steam produced on combustion and by the subsequent cooling of the condensed water down to 60° F., is included. When the two last named amounts of heat are not included, the *net* caloric value is obtained. In most calorimeters the water produced by combustion is condensed.

The latent heat of water is 80 (gram-deg. C.) or 144 in B.Th.U.

The latent heat of steam is 537 (gram deg. C.) or 967 in B.Th.U.

* The joule is the practical unit of work in the C.G.S. system. It equals 10 million (or 10⁷) absolute units of work (ergs).

THE DETERMINATION OF THE CALORIFIC POWER OF FUEL BY THOMPSON'S CALORIMETER.

Although recent comparative experiments with different types of calorimeter* have conclusively proved the superiority of Mahler's Bomb Calorimeter above all other forms, still, owing to the expense of the instrument, it seems unlikely to come into general use at present. And since Thompson's Calorimeter is so largely used, the following details of manipulation are given, so that the best results the instrument is capable of giving may be obtained.†

In the first place it should be noted that for coals of an anthracitic character, yielding more than 87 per cent. of coke, or for coke itself, Thompson's Calorimeter is not suited as an indicator of their comparative calorific power, for the simple reason that some of the carbon is so graphitic in its nature that it will not burn perfectly when mixed with nitrate and chlorate of potash; but with bituminous and semi bituminous coals the apparatus yields very satisfactory results.

Preparation of the sample of coal.—Sample the coal until an average portion passes through an 8-mesh sieve. Take about 20 grams of this and run through a 64-mesh sieve, taking care that the whole sample selected is thus treated. Then dry at 100° C., and use the dried coal for making the determination.

Preparation of the oxidizing mixture.—Potassium nitrate and chlorate are used in the proportion of 1 part of nitrate to 3 of chlorate. These are first thoroughly dried, ground separately, and sifted through a 30-mesh sieve, a finer powder being prejudicial. The powders are then mixed in the proportions stated, and kept in a well-stoppered bottle.

Preparation of the wick.—Oxford cotton is soaked in a moderately strong solution of potassium nitrate, and dried. When dry, it should burn a little too quickly. It should then be rubbed between two pieces of cloth until it burns just freely enough. Four cotton strands are twisted together, cut into $\frac{3}{4}$ -inch lengths, thoroughly dried, and put into a bottle.

The process.—Before weighing out the coal, etc., read the temperature of the room, and regulate the temperature of the water used by the following table.

Temperature of room.	Water should be at.
80° F. (26.7° C.)	70° F. (21.1° C.)
72° (22.2° C.)	64° (17.8° C.)
67° (19.4° C.)	60° (15.6° C.)
60° (15.6° C.)	54° (12.2° C.)
55° (12.8° C.)	50° (10° C.)
50° (10° C.)	46° (7.8° C.)
42° (5.6° C.)	40° (4.4° C.)

* See paper by Brame and Coway, *J.N.C.I.*, 1903, p. 1230.

† The details given are condensed from the valuable paper by J. W. Thomas in the *Chemical News*, 25th March 1881, p. 135, with additions by the author.

Instead of simply filling up to the 29,010 grain mark, it is more accurate to measure out 2 litres, less 116 c.c., since 29,010 grams of water occupy 1881 c.c. A tall narrow cylinder with a single mark serves to measure the 116 c.c. to be withdrawn from the second litre before pouring in. Put a thermometer into the water and leave it there while weighing out the coal. 30 grams of the dried coal are intimately mixed with 330 grams of the oxygenizing mixture; best with a spatula rather than in a mortar. Introduce the mixture into the cylinder (3½ x 11) pressing down in small portions at a time with a test tube; do not tap. Put in the fuse, opening out its lower end in the mixture. Then read the thermometer, light the fuse and place the cylinder, with its stand and cover, quickly in the jar. The combustion should occupy between one and two minutes. At its conclusion the stopcock is opened and the hole moved up and down in the liquid with the thermometer, the latter being read three or four times, and its maximum reading noted. An example will show the mode of calculating results.

Temperature of room	60 F
" water after combustion	67.1
" " before combustion	54.4
	<hr/>
	Increase
	+ 12.7
	<hr/>

Evaporative power of the coal, i.e. number of lb. of water at 212° F. evaporated by 1 lb. of the dried coal, 13.97

$13.97 \times 537 = 7502$ calories, i.e. grams of water heated 1° C. by 1 gram of the coal.

$13.97 \times 967 = 13509$ British Thermal Units, or number of lb. of water heated through 1° Fahr. by 1 lb. of the coal.

The evaporative power of the coal in its original state can be calculated as follows:—

Suppose the above coal to have 11.5 per cent. of moisture, then 1 lb. contains .885 lb. of dry coal,
and .115 lb. of moisture,

$$.885 \times 13.97 = 12.36$$

The quantity of heat required to raise .115 lb. of water from 60° to 212° F., and to convert the boiling water into steam, is

$$.115 \times (152 + 967) = 115 \text{ pound-degree Fahr. units,}$$

which has an evaporative power of

$$\frac{.115 \times 115}{.967} = 0.13 \text{ lb.}$$

* An addition of 10 per cent. is made to allow for the heat absorbed by the copper cylinder and stand and for carbon not completely burned. It has been found to be too small in most cases, and an increase to 15 per cent. has been suggested by Scheurer-Kestner.

Hence the evaporative power of the original coal is $12.36 \cdot 13 = 12.23$ lb.

Since $\frac{1119}{967} = 1.16$, the amount to be finally deducted is obtained by simply multiplying this number by the amount of water contained in 1 lb. of coal.

When the ultimate analysis of a dry coal is known, the calorific value (in calories) can be *approximately* calculated by the following formula :

$$Q = \frac{1}{100} \left\{ 8140 C + 34500 \left(\frac{H}{8} + \frac{(O+N)}{8} + 1 \right) + 2220 S \right\} \\ - 81.4 C + 43.125 \left(\frac{H}{8} + \frac{(O+N)}{8} + 1 \right) + 22.2 S.$$

Thus, the analysis of a *dry* coal gave

$$C \ 90.09 ; H \ 3.85 ; (O+N) \ 3.61 ; S \ 0.77.$$

$$\text{Hence } Q = 81.4 \times 90.09 + 43.125 \left\{ 8 \times 3.85 + 3.61 + 1 \right\} \\ + 22.2 \times 0.77 \\ = 7333 + 1216 + 17 \\ = 8566$$

Mahler's calorimeter gave 8629 calories.

ELECTRICAL UNITS.

The *ohm* is the resistance offered to an unvarying electric current by a column of mercury at 0° C., 14.4521 grams in mass, of a constant cross-sectional area, and of a length of 106.3 cm.

The *ampere* is represented by the unvarying electric current which, when passed through a 10 per cent. aqueous solution of silver nitrate, deposits silver at the rate of 0.001118 gram per second.

The *volt* is the electrical pressure that, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere, and which is represented by $0.6974 \left(\frac{1000}{1434} \right)$ of the electrical pressure at 15° C. between the poles of a standard Clark's Cell.

TABLE OF ELECTRO-CHEMICAL EQUIVALENTS.
(In grams per coulomb. *)

Hydrogen	0.0010384	Iron (ous)	0.0002902
Potassium	0.0004053	" (ic)	0.0001935
Sodium	0.0002388	Nickel	0.0003043
Gold	0.0006791	Zinc	0.000337
Silver	0.001118	Lead	0.001044
Copper (ic)	0.0003281		
" (ous)	0.0006562	Oxygen	0.0008286
Mercury (ic)	0.0010374	Chlorine	0.0004673
" (ous)	0.0020748	Iodine	0.001314
Tin (ic)	0.0003058	Bromine	0.0008282
" (ous)	0.0006116	Nitrogen	0.0000485

* The coulomb is the quantity of electricity conveyed by a current of one ampere in one second (also called an ampere-second).

The values given on p. 164 are obtained by multiplying 0.00010384 (the electro-chemical equivalent of hydrogen) by the fraction $\frac{\text{atomic weight}}{\text{valency}}$ of each element.

The prefix meg- means a million times the unit to which it is prefixed.

The prefix micro- means a millionth part of the unit to which it is prefixed.

Thus a megohm is a million ohms, and 1 microvolt is a millionth of a volt.

The watt is the power of a current of 1 ampere flowing under a pressure of 1 volt. It equals $\frac{1}{746}$ of one horse power.

1 kilowatt = 1000 watts = 1.34 horse power.

134 horse power.

1 electrical horse power = 746 watts = 33,000 ft. lb. per min.

1 B.T.U. = 778.169 watt-seconds, or 36×10^6 watt-seconds.

1 kilowatt-hour = 134 horse-power hours.

1 French or metric horse power = 75 kilogrammetres per sec.

= 32.519 ft.-lb. per min.

= 736 watts.

0.9863 British horse-power.

1 British horse power = 1013.65 French horse-power (force cheval).

Board of Trade Unit (B.T.U.). For commercial purposes electrical energy is measured in units of 1000 watt-hours each, known as Board of Trade units.

$$1 \text{ B.T.U.} = \frac{1000}{746} = 1\frac{1}{3} \text{ horse power-hours.}$$

RULES FOR THE CONVERSION OF THERMOMETRIC DEGREES FROM ONE SCALE INTO ANOTHER.

To Convert	Rules
° F. into ° C.	First subtract 32, then multiply by 5 and divide by 9.
° F. into ° R.	First subtract 32, then multiply by 4 and divide by 9.
° C. into ° F.	Multiply by 9 and divide by 5, then add 32.
° C. into ° R.	Multiply by 4 and divide by 5.
° R. into ° F.	Multiply by 9 and divide by 4, then add 32.
° R. into ° C.	Multiply by 5 and divide by 9.

Note.—Perhaps the simplest rule for the conversion of °C. into °F. is the following:—

Double the number of degrees, subtract one-tenth, then add 32

• Thus

$$99^{\circ} \text{ C.} = 90 \times 2 - 180 = 162 + 32 = 194^{\circ} \text{ F.}$$

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE I. . .

FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.
500	208	260	452	186.7	233.3	404	165.3	206.7
499	207.6	259.4	451	186.2	232.8	403	164.9	206.1
498	207.1	258.9	450	185.8	232.2	402	164.4	205.6
497	206.6	258.3	449	185.3	231.7	401	164	205
496	206.2	257.8	448	184.9	231.1	400	163.6	204.4
495	205.8	257.2	447	184.4	230.6	399	163.1	203.9
494	205.3	256.7	446	184	230	398	162.7	203.3
493	204.9	256.1	445	183.6	229.4	397	162.2	202.8
492	204.4	255.6	444	183.1	228.9	396	161.8	202.2
491	204	255	443	182.7	228.3	395	161.3	201.7
490	203.6	254.4	442	182.2	227.8	394	160.9	201.1
489	203.1	253.9	441	181.8	227.2	393	160.4	200.6
488	202.7	253.3	440	181.3	226.7	392	160	200
487	202.2	252.8	439	180.9	226.1	391	159.6	199.4
486	201.8	252.2	438	180.4	225.6	390	159.1	198.9
485	201.3	251.7	437	180	225	389	158.7	198.3
484	200.9	251.1	436	179.6	224.4	388	158.2	197.8
483	200.4	250.6	435	179.1	223.9	387	157.8	197.2
482	200	250	434	178.7	223.3	386	157.3	196.7
481	199.6	249.4	433	178.2	222.8	385	156.9	196.1
480	199.1	248.9	432	177.8	222.2	384	156.4	195.6
479	198.7	248.3	431	177.3	221.7	383	156	195
478	198.2	247.8	430	176.9	221.1	382	155.6	194.4
477	197.8	247.2	429	176.4	220.6	381	155.1	193.9
476	197.3	246.7	428	176	220	380	154.7	193.3
475	196.9	246.1	427	175.6	219.4	379	154.2	192.8
474	196.4	245.6	426	175.1	218.9	378	153.8	192.2
473	196	245	425	174.7	218.3	377	153.3	191.7
472	195.6	244.4	424	174.2	217.8	376	152.9	191.1
471	195.1	243.9	423	173.8	217.2	375	152.4	190.6
470	194.7	243.3	422	173.3	216.7	374	152	190
469	194.2	242.8	421	172.9	216.1	373	151.6	189.4
468	193.8	242.2	420	172.4	215.6	372	151.1	188.9
467	193.3	241.7	419	172	215	371	150.7	188.3
466	192.9	241.1	418	171.6	214.4	370	150.2	187.8
465	192.4	240.6	417	171.1	213.9	369	149.8	187.2
464	192	240	416	170.7	213.3	368	149.3	186.7
463	191.6	239.4	415	170.2	212.8	367	148.9	186.1
462	191.1	238.9	414	169.8	212.2	366	148.4	185.6
461	190.7	238.3	413	169.3	211.7	365	148	185
460	190.2	237.8	412	168.9	211.1	364	147.6	184.4
459	189.8	237.2	411	168.4	210.6	363	147.1	183.9
458	189.3	236.7	410	168	210	362	146.7	183.3
457	188.9	236.1	409	167.6	209.4	361	146.2	182.8
456	188.4	235.6	408	167.1	208.9	360	145.8	182.2
455	188	235	407	166.7	208.3	359	145.3	181.7
454	187.6	234.4	406	166.2	207.8	358	144.9	181.1
453	187.1	233.9	405	165.8	207.2	357	144.4	180.6

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE I.—continued.

FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.	FAHR.	Reaum.	Cent.
356	141	180	368	122.7	153.3	260	100.3	126.7
355	143.6	179.4	367	122.1	152.8	259	100.2	126.1
354	143.1	178.9	366	121.8	152.2	258	100.4	125.6
353	142.7	178.3	365	121.3	151.7	257	100.1	125.0
352	142.2	177.8	364	120.9	151.1	256	99.6	124.4
351	141.8	177.2	363	120.4	150.6	255	99.1	123.9
350	141.3	176.7	362	120.0	150.0	254	98.7	123.3
349	140.9	176.1	361	119.6	149.4	253	98.2	122.8
348	140.4	175.6	360	119.1	148.9	252	97.8	122.2
347	140	175	359	118.7	148.3	251	97.3	121.7
346	139.6	174.4	358	118.2	147.8	250	96.9	121.1
345	139.1	173.9	357	117.8	147.2	249	96.4	120.6
344	138.7	173.3	356	117.3	146.7	248	96	120
343	138.2	172.8	355	116.9	146.1	247	95.6	119.4
342	137.8	172.2	354	116.4	145.6	246	95.1	118.9
341	137.3	171.7	353	116	145	245	94.7	118.3
340	136.9	171.1	352	115.6	144.4	244	94.2	117.8
339	136.4	170.6	351	115.1	143.9	243	93.8	117.2
338	136	170	350	114.7	143.3	242	93.3	116.7
337	135.6	169.4	349	114.2	142.8	241	92.9	116.1
336	135.1	168.9	348	113.8	142.2	240	92.4	115.6
335	134.7	168.3	347	113.3	141.7	239	92	115
334	134.2	167.8	346	112.9	141.1	238	91.6	114.4
333	133.8	167.2	345	112.4	140.6	237	91.1	113.9
332	133.3	166.7	344	112	140	236	90.7	113.3
331	132.9	166.1	343	111.6	139.4	235	90.2	112.8
330	132.4	165.6	342	111.1	138.9	234	89.8	112.2
329	132	165	341	110.7	138.3	233	89.3	111.7
328	131.6	164.4	340	110.2	137.8	232	88.9	111.1
327	131.1	163.9	339	109.8	137.2	231	88.4	110.6
326	130.7	163.3	338	109.3	136.7	230	88	110
325	130.2	162.8	337	108.9	136.1	229	87.6	109.4
324	129.8	162.2	336	108.4	135.6	228	87.1	108.9
323	129.3	161.7	335	108	135	227	86.7	108.3
322	128.9	161.1	334	107.6	134.4	226	86.2	107.8
321	128.4	160.6	333	107.1	133.9	225	85.8	107.2
320	128	160	332	106.7	133.3	224	85.3	106.7
319	127.6	159.4	331	106.2	132.8	223	84.9	106.1
318	127.1	158.9	330	105.8	132.2	222	84.4	105.6
317	126.7	158.3	329	105.3	131.7	221	84	105
316	126.2	157.8	328	104.9	131.1	220	83.6	104.4
315	125.8	157.2	327	104.4	130.6	219	83.1	103.9
314	125.3	156.7	326	104	130	218	82.7	103.3
313	124.9	156.1	325	103.6	129.4	217	82.2	102.8
312	124.4	155.6	324	103.1	128.9	216	81.8	102.2
311	124	155	323	102.7	128.3	215	81.3	101.7
310	123.6	154.4	322	102.2	127.8	214	80.9	101.1
309	123.1	153.9	321	101.8	127.2	213	80.4	100.6

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE I.—*continued*

FAHR.	REUM.	CENT.	FAHR.	REUM.	CENT.	FAHR.	REUM.	CENT.
212	80.0	100.0	164	58.7	73.3	116	37.3	46.7
211	79.6	99.4	163	58.2	72.8	115	36.9	46.1
210	79.1	98.9	162	57.8	72.2	114	36.4	45.6
209	78.7	98.3	161	57.3	71.7	113	36.0	45.0
208	78.2	97.8	160	56.9	71.1	112	35.6	44.4
207	77.8	97.2	159	56.4	70.6	111	35.1	43.9
206	77.3	96.7	158	56.0	70.0	110	34.7	43.3
205	76.9	96.1	157	55.6	69.4	109	34.2	42.8
204	76.4	95.6	156	55.1	68.9	108	33.8	42.2
203	76.0	95.0	155	54.7	68.3	107	33.3	41.7
202	75.6	94.4	154	54.2	67.8	106	32.9	41.1
201	75.1	93.9	153	53.8	67.2	105	32.4	40.6
200	74.7	93.3	152	53.3	66.7	104	32.0	40.0
199	74.2	92.8	151	52.9	66.1	103	31.6	39.4
198	73.8	92.2	150	52.4	65.6	102	31.1	38.9
197	73.3	91.7	149	52.0	65.0	101	30.7	38.3
196	72.9	91.1	148	51.6	64.4	100	30.2	37.8
195	72.4	90.6	147	51.1	63.9	99	29.8	37.2
194	72.0	90.0	146	50.7	63.3	98	29.3	36.7
193	71.6	89.4	145	50.2	62.8	97	28.9	36.1
192	71.1	88.9	144	49.8	62.2	96	28.4	35.6
191	70.7	88.3	143	49.3	61.7	95	28.0	35.0
190	70.2	87.8	142	48.9	61.1	94	27.6	34.4
189	69.8	87.2	141	48.4	60.6	93	27.1	33.9
188	69.3	86.7	140	48.0	60.0	92	26.7	33.3
187	68.9	86.1	139	47.6	59.4	91	26.2	32.8
186	68.4	85.6	138	47.1	58.9	90	25.8	32.2
185	68.0	85.0	137	46.7	58.3	89	25.3	31.7
184	67.6	84.4	136	46.2	57.8	88	24.9	31.1
183	67.1	83.9	135	45.8	57.2	87	24.4	30.6
182	66.7	83.3	134	45.3	56.7	86	24.0	30.0
181	66.2	82.8	133	44.9	56.1	85	23.6	29.4
180	65.8	82.2	132	44.4	55.6	84	23.1	28.9
179	65.3	81.7	131	44.0	55.0	83	22.7	28.3
178	64.9	81.1	130	43.6	54.4	82	22.2	27.8
177	64.4	80.6	129	43.1	53.9	81	21.8	27.2
176	64.0	80.0	128	42.7	53.3	80	21.3	26.7
175	63.6	79.4	127	42.2	52.8	79	20.9	26.1
174	63.1	78.9	126	41.8	52.2	78	20.4	25.6
173	62.7	78.3	125	41.3	51.7	77	20.0	25.0
172	62.2	77.8	124	40.9	51.1	76	19.6	24.4
171	61.8	77.2	123	40.4	50.6	75	19.1	23.9
170	61.3	76.7	122	40.0	50.0	74	18.7	23.3
169	60.9	76.1	121	39.6	49.4	73	18.2	22.8
168	60.4	75.6	120	39.1	48.9	72	17.8	22.2
167	60.0	75.0	119	38.7	48.3	71	17.3	21.7
166	59.6	74.4	118	38.2	47.8	70	16.9	21.1
165	59.1	73.9	117	37.8	47.2	69	16.4	20.6

THERMOMETRIC TABLES.

169

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE I.—continued.

Fahr.	Reaum.	Cent.	Fahr.	Reaum.	Cent.	Fahr.	Reaum.	Cent.
68	16.0	20.0	34	0.0	1.1	0	-14.2	-17.8
67	15.6	19.4	33	0.4	0.6	-1	-14.7	-18.3
66	15.1	18.9	32	0.0	0.0	-2	-15.1	-18.9
65	14.7	18.3	31	-0.4	-0.6	-3	-15.6	-19.4
64	14.2	17.8	30	-0.9	-1.1	-4	-16.0	-20.0
63	13.8	17.2	29	-1.3	-1.7	-5	-16.4	-20.6
62	13.3	16.7	28	-1.8	-2.2	-6	-16.9	-21.1
61	12.9	16.1	27	-2.2	-2.8	-7	-17.3	-21.7
60	12.4	15.6	26	-2.7	-3.3	-8	-17.8	-22.2
59	12.0	15.0	25	-3.1	-3.9	-9	-18.2	-22.8
58	11.6	14.4	24	-3.6	-4.4	-10	-18.7	-23.3
57	11.1	13.9	23	-4.0	-5.0	-11	-19.1	-23.9
56	10.7	13.3	22	-4.4	-5.6	-12	-19.6	-24.4
55	10.2	12.8	21	-4.9	-6.1	-13	-20.0	-25.0
54	9.8	12.2	20	-5.3	-6.7	-14	-20.4	-25.6
53	9.3	11.7	19	-5.8	-7.2	-15	-20.9	-26.1
52	8.9	11.1	18	-6.2	-7.8	-16	-21.3	-26.7
51	8.4	10.6	17	-6.7	-8.3	-17	-21.8	-27.2
50	8.0	10.0	16	-7.1	-8.9	-18	-22.3	-27.8
49	7.6	9.4	15	-7.6	-9.5	-19	-22.7	-28.3
48	7.1	8.9	14	-8.0	-10.0	-20	-23.1	-28.9
47	6.7	8.3	13	-8.4	-10.6	-21	-23.6	-29.4
46	6.2	7.8	12	-8.9	-11.1	-22	-24.0	-30.0
45	5.8	7.2	11	-9.3	-11.7	-23	-24.4	-30.6
44	5.3	6.7	10	-9.8	-12.2	-24	-24.9	-31.1
43	4.9	6.1	9	-10.2	-12.8	-25	-25.3	-31.7
42	4.4	5.6	8	-10.7	-13.3	-26	-25.8	-32.2
41	4.0	5.0	7	-11.1	-13.9	-27	-26.2	-32.8
40	3.6	4.4	6	-11.6	-14.4	-28	-26.7	-33.3
39	3.1	3.9	5	-12.0	-15.0	-29	-27.1	-33.9
38	2.7	3.3	4	-12.4	-15.6	-30	-27.6	-34.4
37	2.2	2.8	3	-12.9	-16.1	-31	-28.0	-35.0
36	1.8	2.2	2	-13.3	-16.7			
35	1.3	1.7	1	-13.8	-17.2			

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE II.

Cent.	Reaum.	Fahr.	Cent.	Reaum.	Fahr.	Cent.	Reaum.	Fahr.
260	208	500	252	201.6	485.6	244	195.2	471.2
259	207.2	498.2	251	200.8	483.8	243	194.4	469.4
258	206.4	496.4	250	200	482	242	193.6	467.6
257	205.6	494.6	249	199.2	480.2	241	192.8	465.8
256	204.8	492.8	248	198.4	478.4	240	192	464
255	204	491	247	197.6	476.6	239	191.2	462.2
254	203.2	489.2	246	196.8	474.8	238	190.4	460.4
253	202.4	487.4	245	196	473	237	189.6	458.6

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE II.—continued.

CELT.	Reaum.	Fahr.	CELT.	Reaum.	Fahr.	CELT.	Reaum.	Fahr.
236	188.8	456.8	188	150.4	370.4	140	112	284
235	188	455	187	149.6	368.6	139	111.2	282.2
234	187.2	453.2	186	148.8	366.8	138	110.4	280.4
233	186.4	451.4	185	148	365	137	109.6	278.6
232	185.6	449.6	184	147.2	363.2	136	108.8	276.8
231	184.8	447.8	183	146.4	361.4	135	108	275
230	184	446	182	145.6	359.6	134	107.2	273.2
229	183.2	444.2	181	144.8	357.8	133	106.4	271.4
228	182.4	442.4	180	144	356	132	105.6	269.6
227	181.6	440.6	179	143.2	354.2	131	104.8	267.8
226	180.8	438.8	178	142.4	352.4	130	104	266
225	180	437	177	141.6	350.6	129	103.2	264.2
224	179.2	435.2	176	140.8	348.8	128	102.4	262.4
223	178.4	433.4	175	140	347	127	101.6	260.6
222	177.6	431.6	174	139.2	345.2	126	100.8	258.8
221	176.8	429.8	173	138.4	343.4	125	100	257
220	176	428	172	137.6	341.6	124	99.2	255.2
219	175.2	426.2	171	136.8	339.8	123	98.4	253.4
218	174.4	424.4	170	136	338	122	97.6	251.6
217	173.6	422.6	169	135.2	336.2	121	96.8	249.8
216	172.8	420.8	168	134.4	334.4	120	96	248
215	172	419	167	133.6	332.6	119	95.2	246.2
214	171.2	417.2	166	132.8	330.8	118	94.4	244.4
213	170.4	415.4	165	132	329	117	93.6	242.6
212	169.6	413.6	164	131.2	327.2	116	92.8	240.8
211	168.8	411.8	163	130.4	325.4	115	92	239
210	168	410	162	129.6	323.6	114	91.2	237.2
209	167.2	408.2	161	128.8	321.8	113	90.4	235.4
208	166.4	406.4	160	128	320	112	89.6	233.6
207	165.6	404.6	159	127.2	318.2	111	88.8	231.8
206	164.8	402.8	158	126.4	316.4	110	88	230
205	164	401	157	125.6	314.6	109	87.2	228.2
204	163.2	399.2	156	124.8	312.8	108	86.4	226.4
203	162.4	397.4	155	124	311	107	85.6	224.6
202	161.6	395.6	154	123.2	309.2	106	84.8	222.8
201	160.8	393.8	153	122.4	307.4	105	84	221
200	160	392	152	121.6	305.6	104	83.2	219.2
199	159.2	390.2	151	120.8	303.8	103	82.4	217.4
198	158.4	388.4	150	120	302	102	81.6	215.6
197	157.6	386.6	149	119.2	300.2	101	80.8	213.8
196	156.8	384.8	148	118.4	298.4	100	80	212
195	156	383	147	117.6	296.6	99	79.2	210.2
194	155.2	381.2	146	116.8	294.8	98	78.4	208.4
193	154.4	379.4	145	116	293	97	77.6	206.6
192	153.6	377.6	144	115.2	291.2	96	76.8	204.8
191	152.8	375.8	143	114.4	289.4	95	76	203
190	152	374	142	113.6	287.6	94	75.2	201.2
189	151.2	372.2	141	112.8	285.8	93	74.4	199.4

THERMOMETRIC TABLES.

171

CONVERSION OF THE DIFFERENT THERMOMETRIC SCALES.

TABLE II.—continued.

CENT.	Reaumur.	Fahr.	CENT.	Reaumur.	Fahr.	CENT.	Reaumur.	Fahr.
92	73.6	197.6	49	39.2	102.2	6	4.8	42.8
91	72.8	195.8	48	38.4	101.4	5	4	41
90	72	191	47	37.6	100.6	4	3.2	39.2
89	71.2	192.2	46	36.8	101.8	3	2.4	37.4
88	70.4	190.4	45	36	101	2	1.6	35.6
87	69.6	188.6	44	35.2	101.2	1	0.8	33.8
86	68.8	186.8	43	34.4	100.4	0	0	32
85	68	185	42	33.6	100.6	-1	-0.8	30.2
84	67.2	183.2	41	32.8	105.8	-2	-1.6	28.4
83	66.4	181.4	40	32	101	-3	-2.4	26.6
82	65.6	179.6	39	31.2	102.2	-4	-3.2	24.8
81	64.8	177.8	38	30.4	100.4	-5	-4	23
80	64	176	37	29.6	98.6	-6	-4.8	21.2
79	63.2	174.2	36	28.8	96.8	-7	-5.6	19.4
78	62.4	172.4	35	28	96	-8	-6.4	17.6
77	61.6	170.6	34	27.2	93.2	-9	-7.2	15.8
76	60.8	168.8	33	26.4	91.4	-10	-8	14
75	60	167	32	25.6	89.6	-11	-8.8	12.2
74	59.2	165.2	31	24.8	87.8	-12	-9.6	10.4
73	58.4	163.4	30	24	86	-13	-10.4	8.6
72	57.6	161.6	29	23.2	84.2	-14	-11.2	6.8
71	56.8	159.8	28	22.4	82.4	-15	-12	5
70	56	158	27	21.6	80.6	-16	-12.8	3.2
69	55.2	156.2	26	20.8	78.8	-17	-13.6	1.4
68	54.4	154.4	25	20	77	-18	-14.4	-0.4
67	53.6	152.6	24	19.2	75.2	-19	-15.2	-2.2
66	52.8	150.8	23	18.4	73.4	-20	-16	-4
65	52	149	22	17.6	71.6	-21	-16.8	-5.8
64	51.2	147.2	21	16.8	69.8	-22	-17.6	-7.6
63	50.4	145.4	20	16	68	-23	-18.4	-9.4
62	49.6	143.6	19	15.2	66.2	-24	-19.2	-11.2
61	48.8	141.8	18	14.4	64.4	-25	-20	-13
60	48	140	17	13.6	62.6	-26	-20.8	-14.8
59	47.2	138.2	16	12.8	60.8	-27	-21.6	-16.6
58	46.4	136.4	15	12	59	-28	-22.4	-18.4
57	45.6	134.6	14	11.2	57.2	-29	-23.2	-20.2
56	44.8	132.8	13	10.4	55.4	-30	-24	-22
55	44	131	12	9.6	53.6	-31	-24.8	-23.8
54	43.2	129.2	11	8.8	51.8	-32	-25.6	-25.6
53	42.4	127.4	10	8	50	-33	-26.4	-27.4
52	41.6	125.6	9	7.2	48.2	-34	-27.2	-29.2
51	40.8	123.8	8	6.4	46.4	-35	-28	-31
50	40	122	7	5.6	44.6			

INDEX.

	PAGE
Alcohol Calculations,	126, 127
Alcohol, Correction for Temperature,	127
Alcohol, Rules for Dilution of,	127
Alcoholometry,	120
Alcohol Tables,	121
Alkaline Permanganate Solution,	80
Ammonia, sp. gr. table,	76
Ammonium Molybdate Solution,	43
Approximations,	37
Aqueous Vapour, Tension of,	82
Areas and Volumes of Bodies,	32
Arsenic in Food,	159
Atomic Weights,	1
Barn Gallon,	60
Barytes Tables,	67
Baume's Hydrometer,	73
Beer Analysis Tables,	100, 104
Beer, Original Gravity of,	100
Bi-rotation,	106
Blunt's Modification of Tabarie's Formula,	105
Board of Trade Unit,	165
Boric Acid in Cream,	156
Boric Acid in Food,	159
British Thermal Unit,	160
Brown, Morris, and Millar's Factors,	116
Bitter Analysis Tables,	119
Butter Regulations,	150, 151
Butyro-refractometer, Table for,	148
Calorie, The,	160
Calorific Value of Fuel,	161

	PAGE
Chicory in Coffee,	157
Cochineal Solution,	55
Computation,	36
Congo Red,	55
Copper Salts in Food,	159
Corbyn,	62
Cupric Reducing Power,	111
Data, Various Useful,	32
Densities of Common Substances	64
Drams per lb. into Percentage,	66
Electrical Units,	164
Electro-chemical Equivalents,	164
Evaporative Power,	160
Extract of Beer,	102
Factors for Sugars, Starch, etc.	116
Factors, Various Useful,	32
Fehling's Solution,	114, 118
Food Preservatives,	159
Food Units,	140
Foreign Weights and their Equivalents,	63
Formalin in Food,	159
Freezing Mixtures,	7
Gallium,	99
Gases, Coefficients of Absorption of, in Water,	30
Gases, Correction of Volume for Temperature,	68
Gases, Densities of,	7
Glycerin, sp. gr. of,	79
Gravimetric Factors,	9
Gross Calorific Value,	161
Hardness of Water, Reagents for,	81
Hardness of Water, Table of,	87
Heat, Data in,	160
Hertzfeld's Method of Conversion,	110
Hydrochloric Acid, sp. gr. of,	74
Indicators, Notes on,	54
Indirect Analysis, Examples of,	43
Joule, the,	161 (note)
"K," Values of,	115

	PAGE
Kjeldahl Table,	139
Laennoid,	55
Latent Heat of Water and Steam,	161
Lead in Citric and Tartaric Acids,	157
Ling's Method of Determining Sugars,	118
Litmus Solution,	51
Logarithmic Factors, Use of,	40
Logarithmic Tables,	2
Logarithms, Notes on,	33
Magnesia Mixture,	43
Mechanical Equivalent of Heat,	160
Melting Points of Metals,	8
Mercury, Vapour Pressure of,	71
Methyl Orange,	51
Micron,	58
Mil	58 (note)
Milk Analyses, Calculation of Results of,	152
Milk Regulations,	153
Milk, sp. gr. of,	155
Milk, Table giving Deficiency of Non-fatty Solids in	154
Milk, Table giving Fat Deficiency in,	154
Molecular Rotation,	106
Mutrotation or Mutarotation,	106
Nessler's Solution,	80
Nitrates by Crum's Method, Example of,	95
Nitrates in Water, Determination of,	89
Nitric Acid, sp. gr. of,	74
Nitrites in Water, Detection of,	95
Nitrogen into Ammonia and Albuminoids,	137
Nitrogen into Casein, Gelatin, etc.,	140
Nitrogen, reduction of c.c. to grams,	84
Nitrometer Analysis,	29
Normal Solution, Definition of,	29
Normal Sugar Solution,	107
Obscuration of Spirits,	128
Oils, Fats, and Waxes, Constants of,	113
Oils, Fats, and Waxes, Definitions of,	141
Oxygen, Dissolved, amount of in Distilled Water,	98

Parts per 100,000 into grains per gallon	192
Percentage Compositions. Table of.	44
Percentage into cwt., qrs. and lb. per ton etc.,	66
Phenacetolin,	55
Phenol-phthalein, .	54
Phosphate Tables,	129
Polarimeter Reading, reduction of angle of deviation of degree,	112
Polenske Values of Oil	146
Potash, Caustic, sp. gr. of	77
Potassium and Sodium Chloride. Indirect determination of,	41
Precipitating Powers of the gases	43
Prescriptions, Signs used in writing,	63
Preservatives in Food,	159
Preservatives in Milk and Cream,	156
Proof Spirit,	120
Proof Spirit, American	120
Proteins, Factors for,	149
Quinine,	156
Quinine, Tincture of,	156
Quintal,	61
Reciprocals, Table of,	31
Reichert-Meissl Value of Oils and Fats	146
"Reputed" c.c.	126
Rosolic Acid,	95
Salicylic Acid in Food,	159
Salt in Beer,	104
Saponification Equivalents,	147
Saponification Values of Oils and Fats. Table for,	146
Saturated Solutions of Salts. See Congelers,	78
Sewage Analysis Results. Method of Recording	96
Sewage, Sampling of	96
Sewage Effluents, Standards for,	97
Soda, Caustic, sp. gr. Table,	77
Sodium and Potassium Carbonates. Indirect determination of,	42
Specific Gravity, Correction for Temperature	72 (in 96)
Specific Rotatory Power,	105
Specific Rotatory Power of Carbohydrates	108
Specific Rotatory Power, Examples of,	110

	PAGE
Spirits, Distillation of,	128
Spirits, Rules for finding Dilution of,	128
Standard Solutions, Corrections for Temperature,	36
Starch Indicator,	94
Sugar Solutions, Divisors for,	112
Sulphuric Acid, sp. gr. 1.84,	75
Tablespoonful and Teaspoonful,	62
Tabarie's Formula,	105
Thermo-Chemistry, Data in,	160
Thermometric Degrees, Rules for Conversion of,	165
Thermometric Tables,	166
Thompson's Calorimeter,	162
Thresh's Starch Solution,	95
Titer Test,	112
Ton, Long and Short,	61
Ton, Metric,	61
Ton of Water, Volume of,	57
Turmeric Paper,	55
Twaddell's Hydrometer,	32
United States Weights and Measures,	62
Useful Factors and Data,	32
Volumetric Factors,	23
Water Analysis, Reagents for,	80
Water Analysis Results, Calculation of,	94
Water Analysis Results, Method of Recording,	96
Water Analysis, Tables for,	82
Water, Volume and Density at Different Temperatures,	72
Water, Weight of 1 cubic inch, foot, and yard of,	57
Weights and Measures,	56
Winchester Quart,	62

13-MAR-1925

